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22 August 1985

China Report

ECONOMIC AFFAIRS

ENERGY: STATUS AND DEVELOPMENT --41

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CONTENTS

NATIONAL POLICY

NATION REGISTERS AN ACROSS-THE-BOARD ENERGY INCREASE

HK140416 Beijing CHINA DAILY in English 14 Jul 85 p 1

[By staff reporter Liu Dizhong]

[Text] The energy industry hit new production records in the first half of this year, overtaking its planned quotas.

Liu Xiangyang, chief engineer of the Energy Bureau of the State Economic Commission, told CHINA DAILY that coal, electricity, oil and natural gas production had increased over the same period last year.

The energy industry is developing as fast as it can to serve the increased demand from industry and agriculture. But it has a huge task ahead to meet the country's severe shortage of energy, Liu said.

By the end of June, coal production reached 414 million tons--an increase of 11.8 percent over the same period last year, tantamount to 52.5 percent of this year's State quota.

The continuous growth of the nation's coal production is partly due to the boom of small coal mines run by collectives and individuals. During the first 5 months of this year, more than 61,000 small coal mines produced 87.84 million tons, an increase of 33 percent over the same period last year.

But Liu said that accidents have been increasing in collective and individual-run mines that lack proper safety equipment.

The State is planning to improve its financial and technological assistance to small mines. "We also welcome foreign companies that want to help China boost small-scale coal production," Liu said.

Electricity production during the first half of this year increased to 199.1 billion kilowatt-hours, 9.1 percent more than the same 1984 period. Of these, 42.5 billion kilowatt-hours were generated by thermal power plants, and 156.6 billion kilowatt-hours by hydroelectric power stations.

China also produced 61.46 million tons of crude oil--an increase of 10.9 percent over the same period last year--an average rate of 339.600 tons a day.

Also, the nation produced 6.43 billion cubic metres of natural gas--an increase of 7.3 percent, which constitutes 51.4 percent of this year's planned quotas.

Liu said electricity production in the second half of this year might reach 401-404 billion kilowatt-hours, surpassing the planned quota by 5-8 billion kilowatt-hours.

He also said China was still confidently exploring offshore oil reserves and believes prospects are "quite bright." During the first 5 months of this year 29 foreign companies negotiated joint onshore exploration projects with China in the 10 southern provinces that opened to foreign oil companies early this year.

By the end of June, China had exported 14.27 million tons of crude oil--an increase of 45 percent over last year--mainly to Japan, the Philippines, Singapore, and some West European countries. It also exported 3.23 million tons of coal.

"It is difficult for China to increase oil exports when world supplies surpass demand," Liu said.

CSO: 4010/162

NATIONAL POLICY

PRIMARY ENERGY OUTPUT REFLECTS HEALTHY GROWTH

HK160925 Beijing RENMIN RIBAO OVERSEAS EDITION in Chinese 12 Jul 85 p 3

["Roundup" by reporter Zhang Heping [1728 0149 1627]: "Our Country's Energy Output Increases Steadily"]

[Text] According to state energy departments, the situation of our country's energy production is very good. Last year, our country's primary energy output reached 766 million tons of standard coal, 7.4 percent over that in 1983. This comprised 789 million tons, of raw coal, an increase of 8 percent; and over 370 billion kilowatt-hours of electricity, an increase of 7 percent. In the first half of this year, the output of raw coal, crude oil, and electricity again increased by a fairly big margin as compared with that in the same period last year.

Energy is the strategic focus of our country's economic development. As scheduled, our country's energy output will reach 1.2 billion tons of standard coal by the end of this century.

According to specialists', the situation of our country's energy production is good, and the chief reason for this is that we have adopted a correct policy and have depended on scientific and technological progress. Departments concerned told me that from now on, the policy and focus of our country's energy development are:

--In the coal industry, in addition to building necessary new pits, stress will be laid on technical transformation, reconstruction, and expansion of existing production pits. Mechanization of mining, excavation, and transportation will be developed, mining processes will be improved, and coal dressing and comprehensive use of coal will be developed. Our country has cooperated with Britain to manufacture high-power coal excavators and has signed contracts with Thailand and the Philippines on geological prospecting and technical transformation of small coal mines. China and the United States are cooperating in developing the Shanxi Pingshuo Antaibao open-cut coal mine, which is scheduled for completion in 1987. In the future, in addition to making greater use of foreign capital, it will be necessary to raise domestic capital. Funds will be raised from provinces and cities where coal is in short supply, and these funds will be used for transforming oil pits and building new ones. The stress will be laid on assisting and transforming town and township coal mines so as to gradually achieve regular and safe production there.

--In building the power industry, stress will be laid on thermal power stations in the near future and then gradually shift to hydropower stations. From now on, our country will not build new power plants which use petroleum or natural gas as fuel. In coordination with the development of coal bases, large key thermal power plants will be built in places where electricity loads for ports and railways are concentrated. Specialists concerned hold that our country is rich in hydropower resources and that the utilized portion accounts for less than 10 percent of the hydropower resources which can be developed and utilized. There is great potential. According to reports, our country is building or has planned to build a number of key hydropower stations, including Gezhouba and Sanxia on the upper reaches of the Chang Jiang, Longyangxia on the upper reaches of the Huang He, and Lubuge and Tianshengqiao on the upper reaches of the Hongshui He. It is estimated that by the end of this century, the percentage of China's electricity coming from hydropower will increase from 20 percent at present to about 25 percent. In addition, an appropriate number of nuclear power stations will be built in coastal areas where there is not much coal, in the northeast, east China, and Guangdong.

According to people concerned, there has also been a very big development of our country's power network. At present, the six transprovincial large regional power networks, the northeast, north China, east China, Central China, northwest, and southwest power networks, have been formed. The capacity of four of these power networks exceeds 10 million kilowatts. Recently, the south China power network has also been built, which joins the transmission lines in Guangdong and Guangxi. In places to which these power networks do not extend, local governments, small thermal power stations, windmill power stations, and geothermal power stations in accordance with local resources in order to meet the power supply needs of the vast rural areas and small towns and townships.

--In the petroleum industry, the system of contracted responsibility for crude oil output has been implemented in the past few years, resulting in an increase in output. A portion of the income from output in excess of production targets is used for prospecting and exploitation and for importing advanced technology and equipment. Since China began to cooperate with foreign countries in prospecting for offshore oil through inviting tenders in 1979, oil has been found at the mouth of the Zhu Jiang in the South China Sea and in Bohai Sea waters. Considerable progress has also been made in the waters of the Yinggehai and Beibu Gulf. According to reports, China has opened 10 more provinces and regions, comprising Jiangsu, Zhejiang, Anhui, Fujian, Hunan, Jiangxi, Yunnan, Guizhou, Guiyang, and Guangdong. The China Petroleum Exploitation Company has been specially set up to cooperate with foreign countries in exploiting petroleum resources on land.

The speed and extent of development of energy resources such as coal, oil, and water resources are directly related to the progress of our country's modernization. According to reports, the pace of development of our country's energy resources at present has been affected to a certain extent by limited funds and transportation facilities. According to people concerned, we welcome Overseas Chinese and foreign businessmen to cooperate with us in exploiting energy resources by providing us with technology, equipment, or funds or by other means.

CSO: 4013/153

POWER NETWORK

SICHUAN OFFICIAL PROMOTES GROWTH OF SMALL-SCALE POWER FACILITIES

Chengdu SICHUAN RIBAO in Chinese 13 May 85 p 2

[Article by Niu Bo [3662 3124]]

[Text] "It is imperative that we accelerate local power construction!" This was said at the Third Plenum of the Sixth Provincial Peoples Congress by Hu Zhengli [5170 2473 4409] deputy to the Provincial People's Congress and deputy chief engineer of the Provincial Water Resources and Electric Power Office.

He said: "From the viewpoint of Sichuan's electric power situation, the major networks are primarily responsible for key factories, mines, and enterprises in large cities along the railway as well as in nearby regions. Most other regions are quite far from major networks, and the electricity from these networks is in short supply, so power can only be supplied by local power networks from small hydropower and thermal facilities. Since 1983, the installed capacity of local power systems has already exceeded 1 million kW, of which hydropower has constituted more than 90 percent. Moreover, most of this comes from run-of-river power stations so that during the dry season electricity is in extremely short supply. This requires that we build a number of small hydropower facilities in localities that have the conditions in order to relieve the problems encountered during dry seasons. At the same time, we must build a number of reservoirs to go along with the power stations and power stations with storage capacity, thus increasing the regulatory capability of [these] small hydropower stations.

Hu Zhengli stated that sources of investment in Sichuan's small-scale hydropower and thermal facilities and local power networks had not been stable enough in recent years and that there have been great fluctuations which have been extremely detrimental to construction. In the future we must make prudent policy decisions in our planning, rationally "contract the front," ensure a supply of materials and strive to go into production at an earlier date. At the same time we hope that there will be a fairly stable source of investment.

Hu Zhengli feels that small-scale hydropower stations and thermal power plants are small-scale projects that require little investment, have a short period of construction and yield quick results, there are many areas in which they can be developed, there are many possibilities to be near load centers, they can be developed on the spot and the electricity can be consumed on the spot. These are advantages that large power facilities cannot possibly posses. Accelerating local power construction has special significance for developing the national economy.

CSO: 4013/157

POWER NETWORK

GREATER EFFORT MOUNTED TO SUPPLY POWER TO COASTAL REGIONS

HK210430 Beijing CHINA DAILY in English 21 Jul 85 p 1

[By staff reporter Xu Yuanchao]

[Text] Another 5,000 megawatts of electricity will be generated this year and 70 percent of it will go to ease power shortages in coastal cities and provinces, a State official said.

China has seven regional power grids, which are still not enough to supply electricity to the peak-load areas in southern and eastern coastal provinces.

An official of the Ministry of Water Resources and Electric Power said that some 3,720 megawatts will be added to the three key electric grids in northern and eastern parts of China.

In addition, several thermal power plants will be slated for the next five-year plan (1986-1990) to increase the total capacity to 18,750 megawatts in those areas, she said.

Water and coal reserves are scattered throughout southwest and northwest China. The development of long-distance transmission lines should help improve the severe power shortages in coastal provinces, the official said.

Three transmission lines will dovetail with the power grid in Shanghai. Construction of two 500 kv transmission lines from Anhui and Jiangsu provinces already has begun. They are expected to supply 1,000 megawatts of electricity to Shanghai annually.

The official said that a 500 kv transmission line will be erected between Gezhouba in Hubei Province and Shanghai. The transmission line, will provide Shanghai with 1,200 megawatts annually.

Another 500 kv transmission line is planned between Guangxi Zhuang Autonomous Region and Guangzhou. It will transmit an annual amount of 700 megawatts to Guangzhou. The electricity will be supplied by several hydroelectric power stations on the Hongshui He.

The official said open coastal cities such as Zhanjiang, Beihai, Ningbo, and Wenzhou will benefit from the long-distance transmission.

The nation has obtained foreign capital to import up-to-date equipment and has tried to tap power potential from all sources.

The official added that two joint ventures have been arranged between Guangzhou and foreign firms to build thermal power plants in that southern city.

The central government also has been involved in a joint effort with local enterprises to finance power projects in the seaside resorts of Qingdao and Yantai in Shandong Province.

CSO: 4010/162

POWER NETWORK

BRIEFS

GUANGDONG IMPORTS DIESEL UNITS--In order to ease the current electric power shortage, the provincial government is assisting various localities and cities to import their own diesel power generators. According to initial figures, as of April this year, those localities and cities with a more serious power shortage signed contracts to import diesel generators with a total installed capacity of 250,000 kilowatts capable of generating more than 4 million kilowatt-hours of electricity a day. Importing the diesel generators were Jiangmen, Foshan, Guangzhou, Zhuhai, Shantou, and Zhanjiang, with Jiangmen and Foshan importing the most. These imported generators are comparatively advanced by international standards. According to the contracts, these generators will be generating power within 8 months of the date the contracts are signed. [Text] [Guangzhou NANFANG RIBAO in Chinese 23 Apr 85 p 1]

CSO: 4013/157

HYDROPOWER

SUCCESS OF GEZHOUBA PROJECT UNDERLINED

Beijing GUANGMING RIBAO in Chinese 25 Jun 85 p 1

[Article: "Construction of Gezhouba Project Successful; State Acceptance Committee Reaches Conclusion in Its Appraisal, Inspection and Acceptance; Passenger-Freight Volume Has Increased Since River Was Dammed"]

[Text] Responsible people from all the relevant ministries, committees, provinces, and municipalities as well as the specially formed State Acceptance Committee have engaged in an appraisal, inspection and acceptance of the Gezhouba key water conservancy project. The appraisal signed unanimously by 27 committee members concluded that: "The design of Gezhouba's Er Jiang and San Jiang projects is rational, the quality of the projects has reached design requirements, navigation through the San Jiang project is already normal and the construction of the project is successful."

Before the large dam of the Gezhouba project was damming the river, the annual volume of freight transported on this stretch of river was approximately 3.4 million tons. According to statistics of the Ministry of Communications' Chang Jiang Navigation Management Bureau, in 1984, more than 66,600 vessels passed through Gezhouba's locks, passenger volume totalled 1.7 million, and freight volume totalled 5.52 million tons, a 60 percent increase compared to the period before the river was dammed. Before the dam was built, navigation through the Three Gorges stopped whenever the flow of the river exceeded 36,000 cubic meters per second, and every year navigation was interrupted for one week to half a month. Currently, the river is not closed to navigation unless the flow exceeds 50,000 meters per second. This explains how the Gezhouba project is beneficial to navigation.

When the Gezhouba project was being built, China's water resources and electric power technicians accumulated experiences from home and abroad of dams which were built on rivers with a large amount of silt and started to use China's traditional experience of "restrain the water and block the silt" as well as the results of research since the founding of the People's Republic. Their solution to the silt problem was: "navigation is open in calm water, silt is cleared away by moving water, and machines clear away the accumulated silt." During nearly 4 years of navigation, the scouring sluice has been opened 11 times for 10 to 13 hours each time; machines have been used to clear away 730,000 cubic meters of silt. Currently, very little silt is impeding navigation.

Experience has proved that although the Gezhouba project has not "completely" solved the silt problem, it has at least been "basically successful."

The benefits from the Gezhouba key water conservancy project have come in many forms, and the project pays for itself from electric energy production alone. The total investment budget of this project is 4.848 billion yuan. The completed first stage of the project has used 2.471 billion yuan. Starting 30 July 1981, 7 generating units have one after the other went into production and had generated 18.3 billion kWh by 31 March 1985. According to the state's constant prices, revenue from electric energy production totalled 1.2 billion yuan. In the future, 14 generating units on the river will one after the other go into production, and it is anticipated that on the day construction is completed on the Gezhouba project in 1989, revenue from electric power production will be equal to the total amount of investment.

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HYDROPOWER

ACCELERATING DEVELOPMENT OF HONGSHUI VALLEY

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 5, 12 May 85 pp 1-3

[Outline of discussions by Minister Qian Shengying of the Ministry of Water Resources and Electric Power: "The Pace of Hydropower Development in the Hongshui He River Basin Should Be Accelerated--An Outline of Discussions by Minister Qian Zhengying During Her Visit to Guangxi, Guizhou, and Yunnan Provinces (Autonomous Regions)"]

[Text] From 31 January to 16 February 1985, Minister Qian Zhengying and a group of engineering specialists went to investigate the four hydroelectric power stations at Dahua, Yantan, the Tianshengqiao low dam, and Lubuge in the Hongshui He river basin in Guangxi, Guizhou and Yunnan. They heard reports from the related design academies and engineering bureaus. Along with confirming the achievements at these four power stations they also gave continual instructions and paid special attention to a call for reforms in engineering bureaus. They also exchanged viewpoints with responsible comrades in the three provinces and regions concerning questions related to accelerating development of hydropower in the Hongshui He river basin and reached a consensus. During their time in Guizhou Province, they also came to understand the operational and construction situations at the four hydroelectric power plants at Wujiangdu, Hongfeng, Baihua, and Dongfeng. The following is a reorganized outline of Minister Qian's several discussions concerning ways to accelerate development of hydroelectric power in the Hongshui He river basin.

The Conditions Are Complete and There Is a Need To Accelerate Development of the Hongshui He River Basin

Comrade Qian Shengying said that she had seen four projects under construction. The Dahua generator is already operating and can be completed next year. Preparations for construction are underway at Yantan, while system reforms have provided full conditions for reducing construction times. Power generation by the first generator that was originally scheduled for 1993 may be achieved before 1992 or even earlier if work is done well. Comprehensive development work on the Tianshengqiao low dam is now underway and the work is progressing well. The flow can be blocked in 1985 and it is predicted that the first generator will be generating electricity by 1989. The situation at Lubuge also is quite good. Full development is now underway. The flow can be blocked this year, and the first generator will generate electricity in 1989,

although an effort could be made to generate power by the end of 1988. Overall, she felt that the situation at all four projects under construction is very good. She had discussions in Guizhou and Guangxi concerning the need next to build the Tianshengqiao high dam and called on the Kunming Survey and Design Institute to undertake design work this year and to begin preparations for construction in 1986. Moreover, there also is a need to build the Agang Reservoir. The Tianshengqiao high dam and the Tianshengqiao low dam, as well as Agang and Lubuge, are two groups of inseparable matching sister projects. The benefits of the power stations cannot be fully utilized if they are not constructed in succession. This permits us to decide upon two pending construction projects. Moreover, the Longtan project will be added during the Seventh 5-Year Plan and we can strive to see results by the year 2000. This is the largest hydroelectric power station in the Hongshui He river basin. The different understandings of the water level at Longtan in the past meant that a program was never chosen. During this visit, Guangxi and Guizhou both agreed to an elevation of 400 meters and set the water level. Now, a feasibility report can be prepared and submitted for examination and approval. In this way, the major cascades in the Hongshui He river basin can be developed around the year 2000. Such prospects now are very realistic. Four cascades can be constructed in a single river basin at the same time and they can be put into operation around 1990, to be followed by two or three projects awaiting construction. Six design academies and five construction contingents now are working in the Hongshui He river basin. The cascade development situation now is growing. This is an excellent situation, and the full conditions as well as the need for accelerating development in the Hongshui He river basin now exist. She hopes that these six design academies and five engineering bureaus will develop friendly competition, mutual study, and mutual support to make even better contributions of their own to accelerating development of the Hongshui He river basin.

The Yantan Project Should Become a Good Example of Doing Good Work on the "Second Chapter"

Comrade Qian Zhengying praised the Yantan Hydroelectric Power Station for doing good work in putting in roads, water, and power and leveling the site. She said that work on the Yantan Hydroelectric Power Station began after the 3d Plenum of the 12th CPC Central Committee and that the conditions are complete for doing good work on "Document No 2." Moreover, it is not just normal good work, but has become a model of good work on "Document No 2" and has created new levels. Moreover, doing work on "Document No 2" first of all requires agreement and coordinated efforts. We must foster the initiative of the center and local areas. The center must work together with local areas, with the Ministry of Water Resources and Electric Power, with the autonomous region, with construction units, design units and all types of construction units. In summary, they must work together and give full play to their enthusiasm for socialism. Moreover, we must dare to make reforms. They have adhered to the spirit of reform from the beginning and should continue to do so. Excellent results were achieved by inviting bids for the plant building project and for the clear diversion channel on the left bank. This is an excellent beginning and should be continued. There should be contractual responsibility through bidding for all projects in the Yantan Hydropower

Station. We must not protect the backward. This is essential for accelerating the pace of construction. We also must concentrate on reforms in every link, on reforms in design work and on reforms in final prospecting work to deal correctly with the relationships in all areas. If work is done well, this project is fully capable of generating electricity 1 or 2 years ahead of schedule. In the area of investments, we first of all must guarantee that we do not exceed budgetary estimates and also should exercise conservation so that the units with contractual responsibility have profits and so that the employees receive benefits. Comrade Qian Zhengying encouraged the comrades in the Guangxi Hydroelectric Power Engineering Bureau by saying that inviting bids for parts of the Yantan project has given them the favorable conditions, local manpower and an understanding of the situation, so it will become easier. The unfavorable conditions are that the equipment is a little poor. They must make use of these favorable conditions and do studies of cooperation with other engineering bureaus to overcome unfavorable conditions. They are prepared ideologically and are welcoming the competition. They are striving to meet the standards. If they cannot meet the standards, they must begin with the overall situation and be satisfied with a supporting role. Comrade Qian Zhengying told the representatives of the Gezhouba Engineering Bureau who had contractual responsibility for the diversion project on the left bank at the Yantan Hydropower Station that they should guarantee completion of the diversion project by the end of 1986 and that they should create the conditions for the comprehensive project 1 year in advance. She also said that they should make full estimates of difficulties (high slopes, hard rock) and must not treat them lightly. The third thing she said is that they should have a style of encouragement in unity and cooperation.

The Lubuge Project Should Play a Role as a "Window"

The Lubuge Hydropower Station is the first hydropower project in China to be built with a World Bank loan and a grant from the Government of Australia to develop foreign consultation. Comrade Qian Zhengying pointed out after her investigation that the Lubuge Hydropower Station is a key state project. It has international bidding and implemented contractual responsibility for investments inside China. This is an enormous reform in hydroelectric power construction. The Lubuge Hydropower Station is the first hydroelectric power project in China to be opened to the outside. It is the first "window" to the outside for the hydroelectric power system. This "window" is significant in two ways. The first is that foreigners have used the window to gain an understanding of China, and they now are cooperating directly with us in this work. They have come to recognize China's hydropower staffs, people, engineering and technical staffs and ranks of workers. We certainly wish to strive for the glory and reputation of China in this project. Second, China has used the "window" to absorb foreign capital and to study foreign technical, managerial, and administrative experiences. Those at the project have the responsibility for creating conditions for China's hydroelectric power system to study the advanced experiences of other countries. A few of the units at the work site have the responsibility to lead this study and they should take responsibility for receiving China's hydroelectric power system and introducing it to them and to give them an opportunity to study it. The project now is importing capital, equipment and technology in a comprehensive way and there are full

conditions for another leap in hydropower construction. This propels us toward completing the "second chapter."

The Tianshengqiao Low Dam Project Should Guarantee Progress, Work on the High Dam Project Should Start as Early as Possible

Comrade Qian Zhengying pointed out that under the assistance and guidance of leadership departments at all related levels in the Tianshengqiao low dam project, all related design and construction units have been cooperating closely since work began. The project is now fully underway and there have been great achievements. The situation is excellent. There is one overall demand here, which is that the power generation by the first generator by the end of 1989 be guaranteed. There also is an urgent rate of progress. To deal with this overall demand, Comrade Qian Zhengying discussed the total estimated budget for the project, the importation of foreign capital, the rate of progress in the project, the problem of how the project will deal with floods and other questions. In terms of the rate of progress in the project, there are three problems for 1985. The first is to guarantee that the flow is blocked by the end of the year. The second is excavation for the intake machinery and tunnels. The third is to complete the pressure regulation well tasks and excavation for the plant building as planned. The most important problem is the third one. There can be absolutely no negligence. Any lack of equipment must be dealt with quickly by reallocating the equipment from other units. When discussing the Tianshengqiao high dam project, she said that work should proceed as quickly as possible. Unless the high dam goes into operation, the low dam will be incapable of being fully utilized. The start of the high dam project now is a bit late. Originally, they should have been combined in one project and built basically at the same time. It now has been decided that the first generator in the low dam will start operation during 1989. The high dam should strive for early construction and results. This means that the project that will most closely follow the Tianshengqiao low dam project will be the Tianshengqiao high dam project, followed by the Longtan Hydroelectric Power Station. In view of the overall situation, the earlier the construction of the Tianshengqiao high dam project, the better.

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CSO: 4013/147

PRELIMINARY WORK ON THREE GORGES ACTIVELY UNDER WAY

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 5, 12 May 85 pp 6-7

[Article: "The Situation in Preparatory Work for the Sanxia Project"]

[Text] The feasibility study report on the world-famous Chang Jiang Sanxia [Three Gorges] project has been approved in principle by the State Council. Preliminary preparation work is proceeding urgently. This project is the largest construction project in China since Liberation. It will provide enormous comprehensive benefits and is of strategic significance for quadrupling the total value of industrial and agricultural output by the end of the century. Since Liberation, Chairman Mao, Premier Zhou and leading comrades of the CPC Central Committee have paid a great deal of attention to control of the Chang Jiang and construction of the Sanxia project. They listened to many reports, made personal visits to inspect the sites, and issued important instructions. The CPC Central Committee made special decisions in regard to planning in the Chang Jiang river basin and the Sanxia project at its Chengdu Conference in 1958. With coordination by its brother departments over the past 30-plus years, the Chang Jiang River Basin Planning Office [Chang Jiang Office hereafter] established a basis for development of planning for the Chang Jiang river basin and used it to carry out a large amount of exploration, design and scientific research work for the Sanxia project.

Selection of the dam sites was done after the Chang Jiang Office and the [former] Ministry of Geology had done a large amount of geological prospecting work at 14 dam sections in the Meirentuo and Nanjiguan dam regions. They selected two dam sites at Taipingxi and Sandouping in the Meirentuo dam region for comparison. These two dam sites are about 7 kilometers apart and between 40 and 50 kilometers upstream from Gezhouba. All of the strata are very hard integral quartz diorite and biotite diorite. The engineering geology conditions are basically identical, and both are excellent locations to build high concrete dams. The Taipingxi dam site is in a rather narrow river gorge and would require less concrete. It is possible to avoid flooding Maoping Town. A great deal of underground engineering would be required, however, and the layout of navigational facilities and construction would be rather difficult. The river valley at Sandouping is a bit wider and the construction site covers a broader area. It would involve no underground engineering and there is greater leeway for readjustment of key facilities. After discussion during the State Council Feasibility Study Report Examination and Approval Conference in May 1983, Sandouping was selected as the dam site.

In the area of normal water storage levels, the Chang Jiang Office has studied various programs ranging from 125 to 200 meters over the past 30-plus years. The basic conclusion is that a higher normal water level would lead to increased reservoir flood prevention capacity. Installed generator capacity would be greater and the deepwater channel would be longer. Overall benefits would in turn be larger, but there would be greater losses due to flooding and moving greater numbers of people out of the area. For this reason, the question of moving people and losses due to inundation are important factors in the selection of a normal water level. In early 1983, on the basis of many years of research, the Chang Jiang Office issued a feasibility study report for a program with a normal water storage level of 150 meters. After examination and approval by the State Planning Commission, it has been approved in principle by the State Council. It requires the preliminary design of a program for a 150-meter normal water storage level and a 175-meter-high dam. The number of people who must be moved in the 150-meter program is smaller, roughly equal to the number of people who were moved for the Danjiangkou Reservoir. The overall benefits still are obvious, however. Total reservoir capacity at and below the normal water storage level is 20 billion cubic meters, including 7.3 billion cubic meters in flood prevention reservoir capacity. The extra height of the dam will increase the reservoir flood prevention capacity to 20 billion cubic meters. Floods of a severity occurring every 100 years would not require the use of the Jing Jiang flood diversion region, which can guarantee the safety of the large Jing Jiang dam. For floods of a severity that occur less than once every 100 years, the excess reservoir capacity of the extra tall dam for temporary storage in combination with the Jing Jiang flood diversion project also could guarantee the safety of the large Jing Jiang dam. Total installed capacity at the hydropower station will be 13,000 MW and it will generate an average of 65 billion kWh of electricity a year. This can conserve 35 million tons of coal annually, which is of strategic significance for transforming the coal shortage situation in central and eastern China and for improving energy shortages and distribution in China. The reservoir will be about 500 kilometers long and will flood most of the sections of the Chuan Jiang that have fast currents and dangerous shoals. The installation of a dual-line tri-level boat lock (each level of the boat lock will be similar to the scale of the Nos 1 and 2 locks at Gezhouba, and will be able to pass a 10,000-ton ship) and a vertical boat crane at the pivotal project. Annual one-way passage capacity will be 50 million tons. The regulatory role of the pivotal project can increase the downstream flow rate by 1,400 cubic meters/second. We are preparing to organize a discussion on this program next year.

Many technical and economic problems are involved in the Sanxia project. In order to make construction at Sanxia into a modernized project at advanced world levels, leading comrades in the State Council have emphasized that we should continue to strengthen scientific research work. Some scientific research projects at the Sanxia project have become key state research projects and the State Planning Commission has taken overall responsibility for them. The State Planning Commission now is making arrangements for preparatory scientific research work for the Sanxia project that includes silt and shipping by boat, the ecological environment, electrical power system planning, regional socioeconomic development plans for the Sanxia region,

development of very large equipment and research in hydrology, hydraulics, construction, and other areas. Related departments and units are undertaking this work through a division of labor and cooperation. Among the questions being examined is one that now is receiving universal attention: the effects of silt accumulation on navigation in the backwater region of the reservoir. Besides doing mathematical modeling and research on prototype measurements, the Wuhan Hydropower College, Qinghua University, the Chang Jiang Office, and the Tianjin Water Transport Scientific Research Institute of the Ministry of Communications have carried out silt modeling experiments in four typical river sections. Leading comrades in the State Council have asked that the results of the experiments be submitted in May of this year, with the State Planning Commission to examine them for approval.

In order to deal properly with the question of moving people out of the reservoir region, on the basis of more than 30 years of experience, we have proposed the policy of a change from simply installing migrants elsewhere to a development style of migration work. Construction of the Sanxia project should be accompanied by development of the economic resources of this area to build a wealthy economically-developed area in the Sanxia region. leading comrades in the CPC Central Committee and in the State Council have confirmed this principle. Trials of development style migration work will be developed during 1985.

In order to do good preliminary preparatory work and construction of the overall project at Sanxia, the State Council has decided to establish the China Sanxia Project Development Corporation. A construction preparation office will be built first during the preparatory period, and preliminary forces in all areas will be organized for preliminary preparatory work. The corporation will be the construction unit (General Director) of this project during the construction of the Sanxia project. It will be responsible for management and administration after the project goes into operation.

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HYDROPOWER

MANWAN HYDROPOWER STATION DETAILED

Beijing SHUILI FADIAN [WATER POWER] IN Chinese No 5, 12 May 85 p 47

[Article by Gui Zhugong [2910 4554 0180]: "The Manwan Hydropower Station"]

[Text] The Manwan Hydropower Station is located on the middle reaches of the Lancang Jiang in Yun and Jingdong counties in the western part of Yunnan Province. It is an initial-stage project in the development of the middle reaches of the Lancang Jiang. The Kunming Hydroelectric Power Survey and Design Institute has done a great deal of work in exploration, design, scientific research, and other areas over many years. With joint assistance from the Ministry of Water Resources and Electric Power and the Yunnan Province Provincial People's Government, an inspection was made of the preliminary design of the Manwan Hydropower Station in September 1984, and the Yunnan Province Provincial People's Government reported to the State Planning Commission in December 1984 that they requested that the Manwan Hydropower Station be included in capital construction plans for 1985 in preparation for construction.

The Manwan Hydropower Station is a single hydropower project. The installed capacity in the initial stage will be 1,250 MW with a guaranteed output of 352,000 kW and annual power output of 6.3 billion kWh. Later, after the upstream Xiaowan Hydropower Station cascade is completed, the previous indicators will increase to 1,500 MW, 785,000 kW and 7.795 billion kWh, respectively. The scale of this power station is moderate and inundation losses will be small. The technical and economic indices are excellent, and it is a source of electricity that can be developed in the near future. It will become the primary power station in the Yunnan power system when it is completed.

The Manwan Hydropower Station is a grade-one project. The primary water damming facilities will be single-level ones. Inspection of the preliminary design indicates that the pivotal project has chosen a scheme using a concrete gravity dam physical plant building with overhead drainage. This is designed for floods of a severity occurring once every 1,000 years and could remain fairly integral in ones of a severity of every 5,000 years. The top of the dam will be at an elevation of 999 meters, the maximum dam height is 126 meters and the top of the dam will be 449 meters wide. The design water storage level is 994 meters, equivalent to a reservoir capacity of 920 million cubic meters. The flood drainage and silt discharge facilities will be formed

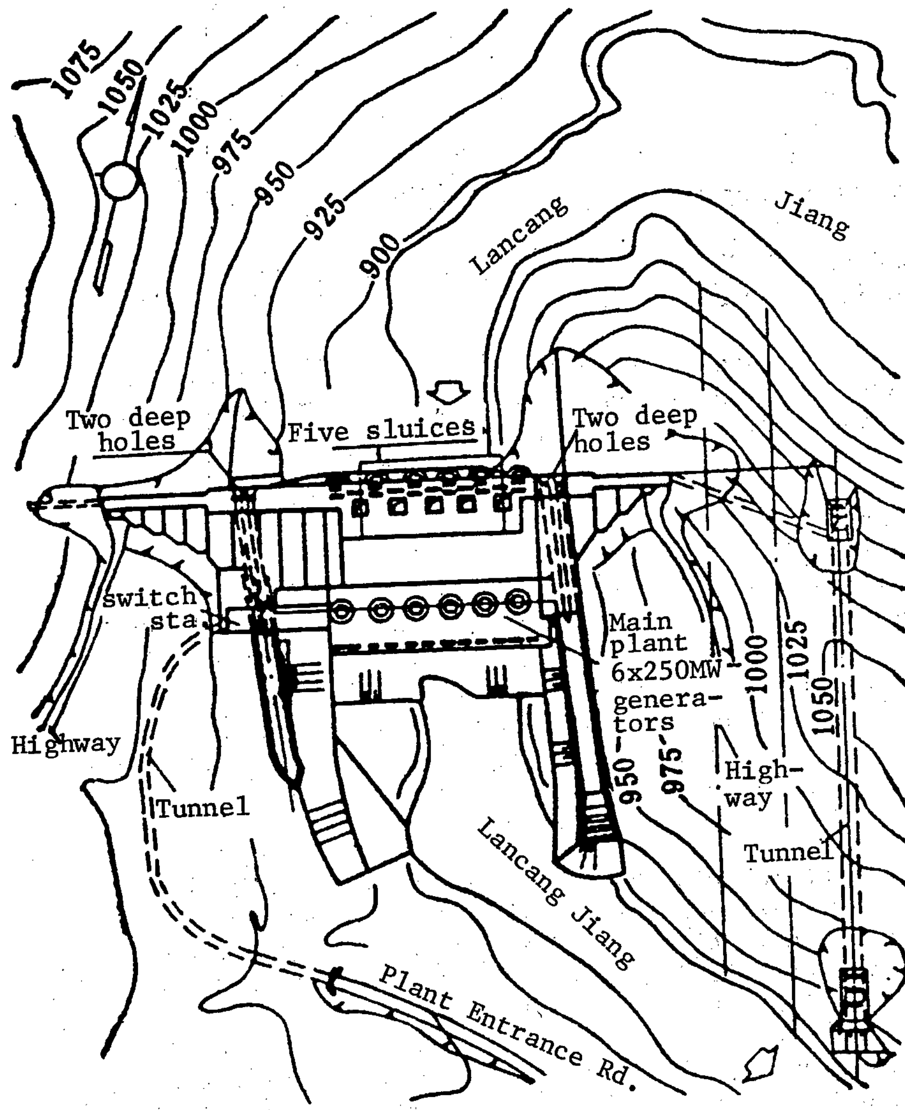
of five surface holes, two bottom holes and a flood discharge tunnel. The flood discharge tunnels will be constructed as diversion tunnels (see figure). The amounts or primary construction work needed for the main body of the power station and the main diversion project will be: clearing 2,325,600 cubic meters of earth, digging out 444,600 cubic meters of stone block, using 2,085,600 cubic meters of concrete and 602,100 cubic meters of earth fill, 70,200 cubic meters of heavy curtain and grouting, and 58,900 cubic meters of refill and joint grouting.

The construction conditions at this power station are rather excellent. The highway from Kunming to Lincang passes on the right bank of the dam site, which helps speed up preparation for construction. Both the right and left banks downstream from the dam site are gentle sloping areas and do not have to be construction sights. The overall layout is shown in the attached figure.

The construction sequence for the project as a whole has been divided into the four stages of preparation for project construction, diversion tunnel and weir construction, construction of the main body of the project and blockage of the diversion tunnels and water accumulation for power generation. There also are other parts of the project that link up the stages. All of the arrangements in preparation for construction can be completed within 4 years of the time that work begins. A program for construction of the diversion tunnel that includes a weir to block the water and year-round diversion on the right bank was adopted. A once-every-20-year-occurrence was adopted as the diversion standard. Excavation of the diversion tunnels can be completed in 11 months during the third and fourth years of construction, and the diversion channels will begin to carry water while the weir blocks the flow. The key part of construction of the main body of the project is the concrete gravity dam, the basic excavation for the power plant building and the pouring of the concrete. It is predicted that excavation of the dam base along both banks can begin during the second quarter of the third year and that the pouring of concrete for the main body of the dam along both banks can begin during the second quarter of the fourth year. It will be completed in the third quarter of the seventh year, which will coincide with the completion of the construction of the concrete plant building and other main parts of the project. The concrete will be poured primarily by using a cable machine supplemented with a high scaffold gate machine. The gates will be lowered to accumulate water in December of the seventh year and the diversion tunnel will be closed. The first generator will be tested and will begin formal generation by the end of the year. Based on the above arrangements, there is a 7-year construction period for the first generator to begin generating and the total construction period (preliminary scale) is 9 years. By preparing to begin digging the diversion tunnels within a year after construction begins, the construction period for power generation by the first generator can be shortened.

The Manwan Hydropower Station is a large-scale joint investment project between a local area and the center. Total investments for the preliminary period of the power station will be 1.04 billion yuan and will total 1.08 billion yuan in the end. The unit investment during the preliminary period is 830 yuan per kW. Yunnan Province will invest 300 million yuan and will

take responsibility for the 3 years of preparation for construction and for construction of parts of the project. Invitation of bids will be used for construction of the project as a whole.



Overall Layout of the Manwan Station Project

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PROBLEMS WITH HYDRAULIC PROJECTS IN HUNAN EXAMINED

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 1, 20 Jan 85 pp 1-10

[Article by Hunan Hydropower Exploration and Design Institute: "Some Problems in Layout, Flood Discharge and Energy Dissipation of Hydrojunctions in the Narrow River Valleys of Hunan"]

[Text] I. Overview

Hunan is situated in south central China and has a humid tropical monsoon climate. It is hot in the summer and precipitation is concentrated. Its annual rainfall is between 1,200 and 1,700 millimeters and its annual runoff is approximately 186.1 billion cubic meters. The whole province is abundant in hydropower resources with a reserve of 15.32 million kilowatts. According to incomplete figures, since the 1950's more than 90 key water conservancy projects with a dam height over 20 meters have been constructed or are being constructed in narrow river valleys to develop and utilize these hydropower resources.

Apart from producing electricity, the key water conservancy projects in Hunan's narrow river valleys generally have concurrent uses for irrigation, flood control, navigation and log passage. Their hydraulic structures are numerous which therefore increase the complexity of the layout of hydrojunctions. Taking into account the high discharge capacity and the numerous opportunities for the use of flood discharge structures in narrow river valleys, the layout is primarily full-bed discharge; half-bed discharge is also arranged in areas with suitable conditions and partial-bed discharge is also utilized. The form of discharge is primarily dam surface discharge (approximately 82.9 percent of the total number of hydrojunctions in narrow valleys). Dam materials mainly consist of concrete and grouted rock, of which the number of grouted rock dams built from local materials constitute 83 percent of the total. With the exception of one project which has adopted undercurrent energy dissipation due to poor geological conditions, all projects have adopted the ski-jump form of energy dissipation.

Most of the key water conservancy projects of the narrow river valleys in Hunan have small storage regulating capacity and many opportunities for discharge so that most projects have experienced relatively large floods.

Their operation has clearly shown that these projects have handled the relationship between flood discharge and electricity generation, navigation, log passage as well as irrigation. They have experienced success but there are some problems in discharge and energy dissipation that deserve attention. This article is a brief introduction and exploration into some of the problems in layout, discharge, and energy dissipation in the narrow river valleys of Hunan.

II. Layout of Hydrojunctions in Narrow River Valleys

The major factors which determine the overall layout of key water conservancy projects are usually the geological, topographical and hydrological characteristics of dam sites; the goals of development and utilization; construction materials as well as construction conditions. Based on such characteristics as high peaks and large flows and frequent appearance of peaks in Hunan's narrow river valleys as well as the contradictions in layout between flood discharge structures and electricity generation and navigation structures, the following types of layout are usually adopted by key water conservancy projects.

1. Full-bed Discharge, Hydropower Stations Arranged on Banks or Using Tunnel Diversion

Projects with this type of layout usually have particularly narrow river beds (ratio of dam crest length and dam height is $L/H \leqslant 3$), high discharge and relatively good topographical conditions for the layout of individual power stations.

(1) Concrete (or Grouted Rock) Gravity Dams

Projects which adopt concrete gravity dams are diamond head single buttress dams such as the Zhexi Hydropower Station with a maximum discharge of 15,460 cubic meters per second. The bucket single-width flow q_{max} after adopting full-bed discharge is still as much as 103 [cubic] meters per second. For this reason, short diversion tunnels are excavated on the left bank of relatively strong rock, and the hydropower station is situated among the toe-of-mountain scour channels. The layout of the hydrojunction is compact, the volume of work is small and management of operation is convenient. As another example, the dam of the Taohuajiang Reservoir is 54 meters high. Usually the river surface is merely 20 meters wide, and after using full-bed discharge, q_{max} = 55.4 square meters per second. The power station is laid out on the col platform of the right bank. Short reinforced steel concrete pipes go through the large dam and mountain for diversion, and the tail and irrigation channels of the power station are combined.

Many grouted rock dams adopt this form of flood discharge layout. For example, the Huangshidong grouted rock gravity dam has a height of 43.5 meters, full-bed discharge, and q_{max} = 51.5 square meters per second. The Yanwutan grouted rock hollow gravity dam has a height of 60 meters, 5 tainter gates of 5 x 9 meters opened up at its crest, full-bed discharge q_{max} = 93.2 square meters per second. The Jinjiadong grouted rock

broken-line gravity dam has a height of 58 meters, and q_{max} = 43.2 square meters per second.

(2) Arch Dams

Concrete arch dams and grouted arch dams using full-bed discharge are also relatively popular. For example, the arch dam of the Ouyanghai Reservoir has a height of 58 meters and a maximum discharge of 6,090 cubic meters per second, and full-bed discharge is carried out by 5 large openings (11.5 x 7 meters) in the dam body. It is the living engineering example of a double-curvature arch dam project with discharge from openings constructed the earliest in China and with the largest diameter of opening (see Figure 1).

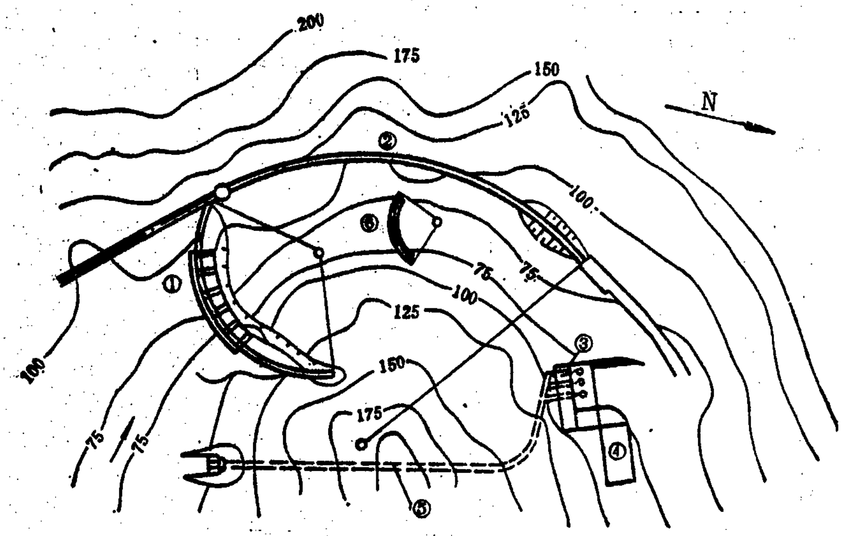

Figure 1. Schematic of Ouyanghai Reservoir Structural Layout
1--Arch dam; 2--Ship lift; 3--Powerhouse of power station; 4--Switch station; 5--Power generation tunnel; 6--Secondary dam

Although the tunnels are relatively long in some cases, since large drops can be obtained because the rivers zigzag and have large gradients, discharge structures are arranged for full bed and power stations are arranged at tunnel exits. For example, the arch dam of the Huamuqiao Reservoir is 37.5 meters in height and has a 4,500-meter long diversion tunnel which gives a highest power generating water head of 150 meters and an installed capacity of 54,000 kilowatts. Floods are discharged from the crest of the arch dam and the highest discharge is 1,510 cubic meters per second.

The earliest arch dam project in Hunan using full-crest overflow is the Banjiang arch dam. The dam is 42 meters high with a crest length of 128.5 meters and the spillway section is 54 meters long (the river is about 20 meters wide). Construction was completed in 1958. The maximum design discharge is 824 cubic meters per second. In order to keep the main current in the middle, the barrage shows a cubic curve variation, and the

elevation of the barrage on each side is 1 meter higher than the middle portion. In this way, medium and small flows generally pass through the middle portion of the crest and fall into the river channel, and during large flows the main current stays in the middle and the currents on both sides are smaller, thereby reducing scouring of the side slopes. Slope protection has not been done on the two banks as the dam site rock (granite sandstone) is relatively perfect, strong and has a high resistance against erosion. For the safety of the dam toe, a 10-meter high secondary dam has been built 50 meters downstream using the terrain. Good results have been achieved during the more than 20 years of operation of the project.

Some double-curvature grouted rock arch dams adopt full-crest overflow. For example, the Maoxi arch dam is 48 meters high, 90 meters long and has an effective overflow width as much as 72 meters and a maximum discharge of 2,170 cubic meters per second. The dam site is limestone and a secondary dam is built downstream for energy dissipation. Since its completion in 1977, the greatest barrage depth of this dam is 3 meters and the project has operated well.

(3) Other Light-Weight Dams

The bottom width of the river valley of the Shuangjiangkou spillway slab dam site (see Figure 2) is just over 10 meters and uses full-bed discharge, with q_{max} = 32.2 square meters per second. The power station is arranged on the slope at the toe of the dam, the buttress cavity on the right side uses piped diversion to generate electricity, and the tail and irrigation channels of the power station are combined. The layout of this project is rational, its antiseismic facilities are simple, convenient and effective, and its operation for 26 years has been outstanding.

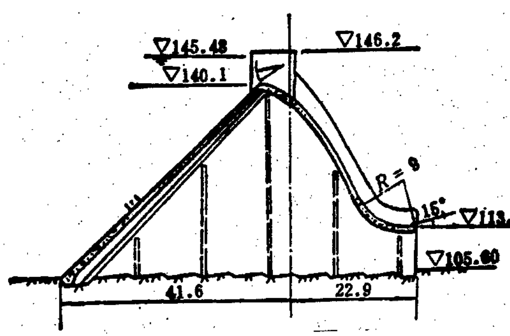

Figure 2. Sectional Schematic of Shuangjiangkou Spillway Dam (Unit: meter)

The advantages in adopting full-bed discharge layout are: separation of powerhouse and dam which can eliminate or reduce the negative effect of discharge on the power station; can avoid interference by construction; reduce silting and deformation of downstream river bed and benefit power generation, flood discharge, navigation and log passage.

2. Partial-Bed Discharge, Power Station Use of Toe-of-Dam Layout

When the river bed is relatively wide (L/H = 3 to 5) and it is possible to place discharge and power generation structures side by side, and when the river is relatively flat and straight and the terrain is not suitable to lay out the power station, most of the bed is usually used for discharge and a small portion of the bed is used for and building toe-of-dam power stations.

(1) Shuangpai Hydropower Station

The Shuangpai Hydropower Station is a half-bed discharge key water conservancy project built relatively early in Hunan. This project is a diamond head double buttress dam with a height of 58.8 meters and was completed in 1961. The river bed of the site is relatively wide (L/H = 5.3 meters) but discharge is relatively high (12,560 cubic meters per second). Moreover, there is a demand on comprehensive utilization for navigation and log passage, power generation and irrigation. The spillway dam section is laid out on the right side of the river bed and has 11 tainter gates of 10 x 9 meters, and q_{max} = 100.5 square meters per second. In order to shorten the length of discharge sections, each gate pier is merely 1.5 meters wide and the total length of the spillway dam section is 136.85 meters or 65.5 percent of the bed width. The powerhouse dam section is closely connected to the layout of the spillway dam section (with an installed capacity of 135,000 kilowatts) which is 72 meters long, constituting 34.5 percent of the width of the entire river bed. The ship locks are laid out on the relatively level left bank slope. The operation for over 20 years has clearly shown that this layout is feasible.

(2) Centianhe Reservoir

The Centianhe Reservoir is primarily for log passing and is a project of comprehensive utilization which also undertakes power generation, irrigation and flood control. It is an upstream cascade of the Shuangpai Hydropower Station and was built on the experience of Shuangpai. This dam is 46 meters high, L/H = 3.43 and the maximum discharge is 6,770 cubic meters per second. The installed capacity of the hydropower station is 22,500 kilowatts and the layout of the hydrojunction demands compactness. Therefore, the method of increasing single-width flow was used to arrange the spillway dam section on the right side of the river bed. The spillway dam section has 5 tainter gates of 10 x 9 meters, and a 4-meter high movable parapet is added to the upper portion of each gate so that the single-width flow is increased to 121 square meters per second. The logway is 6.5 meters high and arranged on the relatively gentle left bank slope. The toe-of-dam powerhouse is placed in the 51-meter section between the logway and the spillway dam section. Because the worksite was short of space, the 35-kilovolt switch station is placed on the top of the powerhouse and the 110-kilovolt transformer station is set up on the tailwater platform. The spillway dam section and the powerhouse dam section take up 60 and 40 percent of the entire river bed respectively. This type of layout is relatively crowded and operation conditions are relatively poor.

(3) Huangtuxi Reservoir

The large dam of the Huangtuxi Reservoir is a 35.5-meter high concrete rock partitioned rubble-filled dam with a crest length of 126.5 meters. The river bed width of the site is approximately 40 meters and the maximum discharge is 2,660 cubic meters per second. The spillway dam section is 50 meters long, has 4 tainter gates of 9 x 9.3 meters, q_{max} = 72.2 square meters per second. The powerhouse of the power station is near the right bank and is the toe-of-dam type. In order to reduce side slope excavation, the powerhouse is laid out along the river (slightly inclined toward the right bank by 30°), and the spillway dam section and the power station make up 71.5 and 28.5 percent of the total width of the river bed respectively (see Figure 3). In view of the fact that this project fills waste in the wide joints of the large dam, it has its own uniqueness and was one of the projects China introduced at the 11th International Congress on Large Dams.

(4) Other Projects

Grouted rock gravity dams which adopt partial bed discharge projects also include the Dajiangbian (whose dam height is 55 meters, L/H = 2.8, q_{max} = 50.8 square meters per second) and the Dazhen (whose dam is 80.3 meters high, L/H = 3.47, q_{max} = 30 square meters per second), and their powerhouses are laid out on the more gentle part of the side slope. The powerhouse tailwater and irrigation channels are combined. Power generation and irrigation are undertaken at the same time.

The characteristics of partial bed discharge layout include compactness, smaller total work volume, more economical investment and convenient management and operation. But during design and operation attention should be paid to handling the negative effect of flood discharge on power generation, navigation and log passage.

3. Spillway and Overlapping Layout of Power Stations

Quite a few key water conservancy projects with narrow river beds, large flood discharge and location on relatively flat and straight river sections at home and abroad adopt the overlapping layout of spillway and power station such as powerhouse within the dam, powerhouse with spillway on top and ski-jump type of powerhouse. The Fengtan hollow gravity dam in Hunan has successfully adopted the within-the-dam type of powerhouse and is a new form of spillway-power station overlapping layout.

The Fengtan hollow gravity dam is 112.5 meters high, its crest is 458 meters long and L/H = 4.33. Its once every 1,000 years flood discharge is 26,000 cubic meters per second which makes it a project with the largest crest overflow in the whole world. The dam crest has 13 tainter gates of 14 x 12 meters and q_{max} = 137.4 square meters per second. The powerhouse within the dam is installed with four 100,000-kilowatt turbine generating units. An inclined ship lift is installed at the right dam head for navigation and log passage. To reduce downstream silting and deformation by small discharge, 13 overflow openings adopt a high-low alternating bucket layout so that

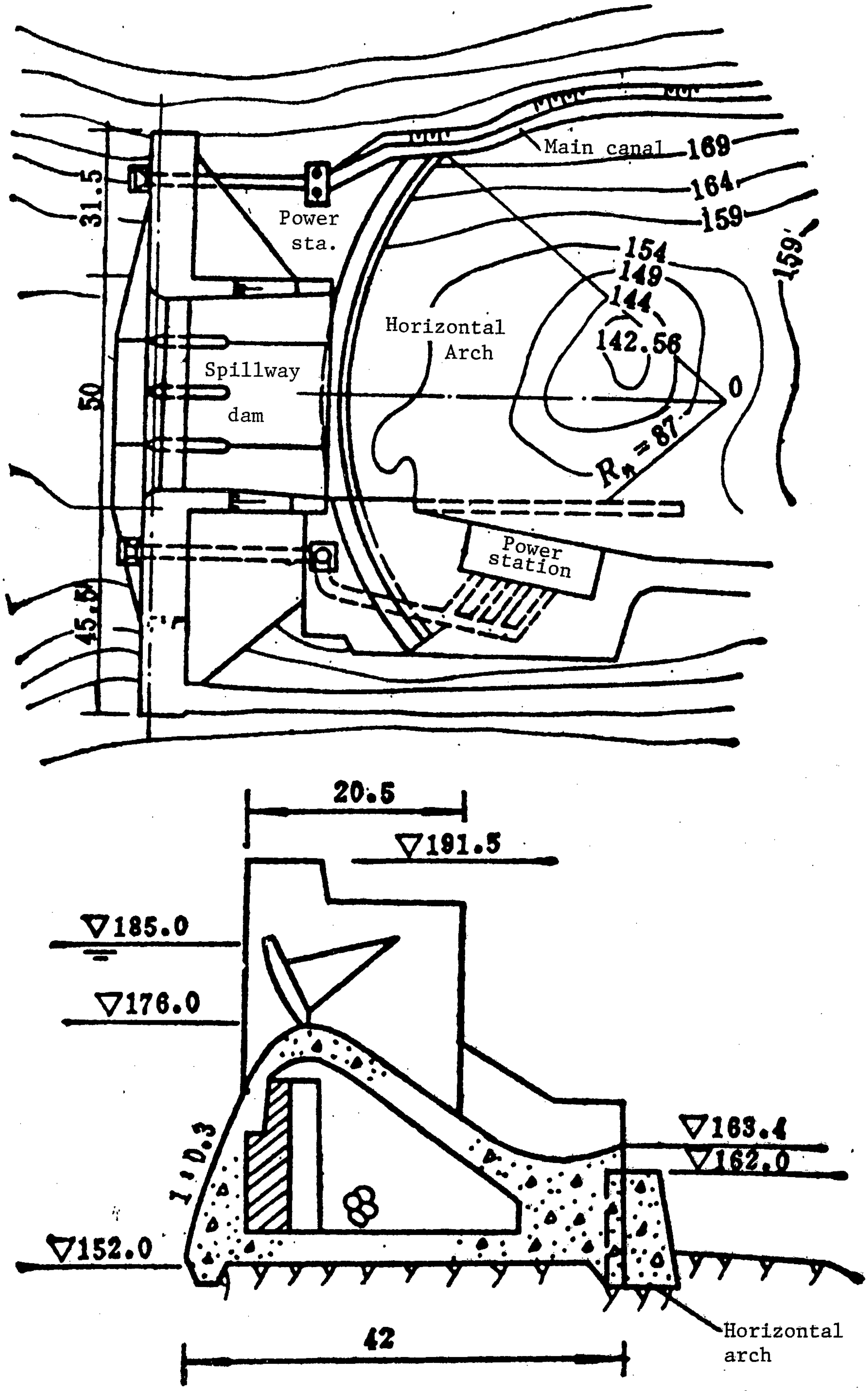

Figure 3. Schematic of Huangtuxi Reservoir Structural Layout
(Unit: meter)

high-velocity currents collide and dissipate energy in the air. In August 1980 after the completion of the project, a flood of 12,500 cubic meters per second was discharged and the project was safe and unaffected.

However, it should be pointed out that for overlapping layout of spillway dams and power plants, construction is more complicated and the operation of power plants is poorer.

4. Bank-Run Spillways

Bank-run layout of spillways is a feasible scheme in the absence of hill openings near dam sites suitable for flood discharge while dam body materials or structural patterns are unsuitable for water passage and bank-run has suitable locations for the excavation of spillways. The layout of ski-jump spillways on both sides of arch dams has become a common form of flood discharge layout, and the Dongjiang arch dam under construction is adopting this form of layout (see Figure 4).

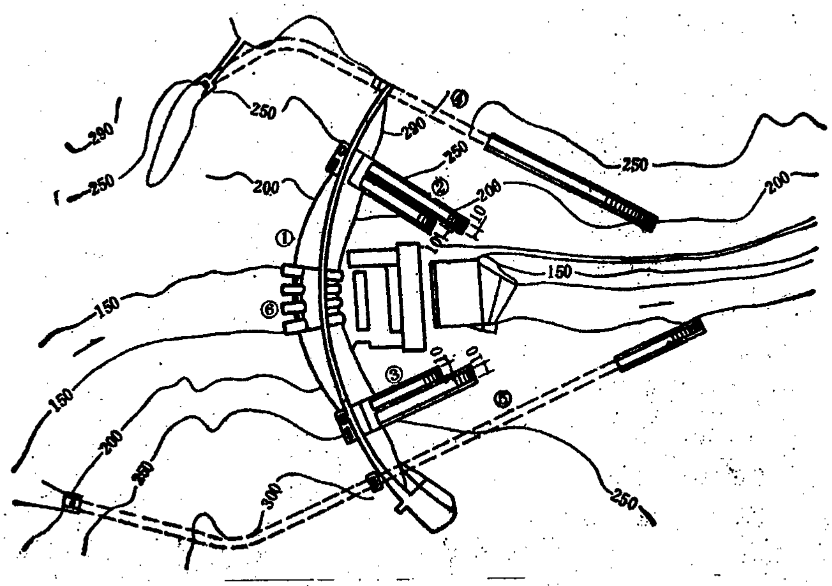

Figure 4. Schematic of Dongjiang Hydropower Station Structural Layout
1--Arch dam; 2--Left bank ski-jump spillway; 3--Right bank ski-jump spillway; 4--Left bank discharge tunnel; 5--Right bank discharge tunnel; 6--Water inlet of power station

The arch dam of the Dongjiang Hydropower Station is 157 meters high. It is a double-curvature thin arch dam with a crest length of 438 meters and L/H = 2.78. The hydrojunction's maximum discharge is 8,260 cubic meters per second, and the discharge structures mainly consist of the ski-jump spillways with 2 openings of 10 x 7.5 meters on each of the two sides and a discharge tunnel of 8.5 x 8 meters. The single-width flow at the ski-jump spillway outlets is as high as 120-150 square meters per second. The power station is situated in the middle of dam toe river bed with an installed capacity of 500,000 kilowatts.

The characteristics of this type of layout are: water discharged through spillways can be moved to areas downstream far away from the dam site so that scour holes will not jeopardize the safety of the large dam and power station; ski-jump spillways are symmetrically arranged on the two sides of the large dam and have certain narrow corners so that downward discharged water can collide with each other and dissipate energy thereby reducing erosion on the river bed downstream; the powerhouse is very close to the lower part of the dam, water conveyance channels are short and the volume of water is small, but there is some interference with plant and dam construction.

III. Some Problems of Flood Discharge and Energy Dissipation

Water conservancy and hydropower projects in Hunan usually adopt surface overflow and ski-jump discharge and energy dissipation. Most of these projects have experienced floods. In the light of some of the facts gathered from operation, some problems can be summarized as follows:

1. Ski-Jump Discharge Erosion and Stability and Skid-Resistance of Dam

(1) Ski-Jump Scouring

The depth of scour caused by ski-jump nappe on river bed downstream is generally estimated from the following formula:

$$T = t + h = Kq^{0.5}H^{0.25}, \qquad (1)$$

In the equation:

T = maximum depth of scour;
t = depth of scour;
h = depth of water above river bed downstream;
K = integral coefficient which mainly reflects scour resistance, related to the formation, structural characteristics and nature of rock;
q = single-width flow of bucket;
H = drop between upstream and downstream.

Based on the scouring in the prototypes of some projects in Hunan using ski-jump discharge and energy dissipation (see Table 1), the value of coefficient K in the above formula under the conditions of different rocks has been analyzed and is a valuable reference in the design of energy dissipation projects.

From the data in Table 1 combined with the data on scouring in some other projects, it can be said that: for flint, quartz sandstone, granite, and other relatively strong rocks which are in large blocks and whose joints are undeveloped, K = 0.7 to 0.9, and 0.8 can be taken as the mean; for sandstone, granite and other rocks which are easily scoured and which are in large blocks and whose joints are more developed, K = 0.9 to 1.2, and 1.1 can be taken as the mean; for rocks which are in broken blocks, whose joints are developed and most of which are slightly opened, K = 1.2 to 1.6, and

Table 1. Downstream Scouring of Some Hunan Water

Name of project	Type of dam	Height of dam (meters)	Geological condition of scoured area	Flow Q (cubic meters per sec)
Zhexi	Diamond head single-buttress dam	104.0	Greyish-green slate and sandstone interbedding; dips 60°-65° downstream; litholigically strong	Maximum 6,026
Shuangpai	Diamond head double-buttress dam	58.8	Purplish red sandstone and slate interbedding; dips 7°-15° downstream	Maximum 6,027
Centianhe	Concrete gravity dam	46	Purplish red fine sand-stone intercalated with quartz sandstone; fault dips 18°-22° downstream	1,080 (actually measured 5/1973)
Shuang-jiangkou	Slab dam	41.6	Quartz sandstone and arenaceous shale	187 (actually measured 1965)
Huangtuxi	Grouted rock partitioned waste-filled dam	35.5	Red sandstone intercalated with pelitic shale; rock strata dip 18°-22° down-stream	1,041 (actually measured 8/1980)
Taohuajiang	Concrete gravity dam	54.0	Flintstone; strong and perfect	491 (actually measured 8/1969)
Huangshidong	Grouted rock gravity dam	43.5	Fine sandstone, joint crevices developed	1,280
Ouyanghai	Double-curvature arch dam	58.0	Granite relatively perfect	
Xiaolongtan	Grouted rock arch dam	36.2	Carbonaceous shale, broken	
Dalongtan	Grouted rock arch dam	16.0	Red sandstone, relatively broken	

Conservancy Projects Using Ski-Jump Energy Dissipation

Bucket lip single-width flow (square meters per sec)	Upstream/ downstream height of water H (meters)	River bed depth of scour (meters)	K	Front slope gradient of scour hole	Remarks
Maximum 84.8	Maximum 69.57	Deepest 18.98	Slate: 1.1 Quartz sandstone: 0.97	1:7	(1) Differential bucket (2) K average taken from 5 observed values of prototype
Maximum 54.1	Maximum 41.07	Deepest 20.16	1.85	1:4.4	K average taken from 10 observed values of prototype
19.3	24.83	8.43	1.76	1:6.25	
5.66	33.47	1.8	0.88		
22.7	24.61	9.4	1.83	1:6.9	
33.6	36.22	6.3	0.72	1:4.2	
26.6	31.6	12	1.60		
46	30.6	5.54	1.09	1:5.9	
2.5		5		1:2	5-7 meters of lower dam protected by concrete, 6.5-meter high secondary dam
14.5 (actually measured 1980)		5		1:2	Dam toe refilled with block stone and concrete

1.4 can be taken as the mean; and for rocks which are in broken blocks whose joints are very developed and have opened up crevices, such as red sandstone, pelitic shale and slate, K = 1.6 to 2.0, and 1.8 can be taken as the mean.

(2) Scouring and Stability of Dam Against Sliding

For the straight-line dam projects listed in Table 1, the gradient of slope in front of scour holes is between 1:4.2 and 1:7.2 and is generally safe. But the deep strata are in danger of sliding when the dam foundation has a gentle inclination and weak intercalated bed.

After more than 10 years of operation of the Shuangpai Reservoir and as a result of supplementary exploration and survey, it is clearly found that weak intercalated bed exists in the dam foundation rock strata with an inclination of 7° to 15° and the gradient of the upstream slope of the scour holes is between 18° to 28°, which seriously jeopardize the safety of the large dam. Therefore it has been necessary to adopt reinforcement measures such as bucket extension and prestressed anchoring of the foundation of the bucket section.

The margin of safety against sliding of the body of the large dam of Huangtuxi Reservoir was inadequate because of higher flood standards, inadequate building capacity of the dam body during construction and scouring below dam. Consequently a horizontal arch was added behind the bucket to enhance dam stability against sliding (see Figure 3). In August 1980, after reinforcements were made to the project, upstream water level of the dam rose as high as 187.15 meters, or 1.85 meters above the flood level of once every 500 years. Correspondingly the downstream water level of the dam also exceeded the verified flood level by 1.24 meters. After the passage of the flood peak, the dam body was fully examined, but no problem was found.

As for the arch dam, most of the load is transferred from the arch ring to the mountain on the two banks so that the conditions for its stability against sliding are clearly better than straight-line dams. But dam crest overflow frequently has a short ski-jump distance and scouring can even reach the toe of dam. For instance, the large dam of the Xiaolongtan Reservoir is 36.2 meters high and its foundation is composed of the relatively broken carbonaceous shale. During its construction flood passage was tried with a single-width flow of 2.5 square meters per second. Scour holes downstream from the dam are 5 meters deep and the gradient of the slope upstream from the scour holes is approximately 1:2. Another example is the large dam of the Dalongtan Reservoir which is 16 meters high and its foundation is composed of the relatively broken red sandstone. [In 1980 the dam overflowed, and flood passage was 14.5 square meters per second with a single-width flow.] Its downstream scour holes are 5 meters deep and the gradient of slope upstream from the scour holes is approximately 1:2. For the sake of safety, these two projects were given suitable reinforcement treatment. For example, 5 to 7 meter long concrete protective reinforcements were used on the slope upstream from the Xiaolongtan scour holes, and a 6.5-meter high secondary dam was built 50 meters downstream from the dam

to increase the thickness of the scour water cushion. For the Dalongtan Reservoir, concrete blocks were used to fill along the dam toe in order to increase the distance of the unscoured area.

2. Effect of Flood Discharge on Power Stations

(1) Overview

Flood discharge has the following effects on power stations: First, direct impact of ski-jump nappe on the side wall of the station's powerhouse causes scouring of the base of the side wall or vibration of the side wall; second, during discharge of the spillway dam section, backflow and cross-gradient develop in the tail channel of the power station or the tailwater is caused to undulate, which affect the stability of power generation; third, flood discharge of the spillway dam section causes silting and deformation of downstream areas of the dam, causes rock waste to enter tail channels, raises the water level downstream and affects the output of the power station; and fourth, misting of the ski-jump nappe affects power transmission and transportation.

(2) Hydrojunctions With Partial-Bed Discharge

The effects described above are most notable in hydrojunctions with partial-bed discharge. Because of the limitations of bed widths, most powerhouses of power stations are arranged next to spillway dams. The threat of ski-jump nappe on powerhouses is relatively direct, and deformation from scouring and silting downstream is also great. In order to avoid impact of ski-jump nappe on the side wall of power stations, the side wall of the spillway dam is usually extended to the top of the bucket, narrowed inward where suitable or patched at the outlets. Nevertheless, frequently inadequate attention is given to the second side-hole near the power station. When the second side-hole is opened, the ski-jump nappe begins to diffuse laterally from the tail portion of the lock pier which pounds on the side wall of the power station and may even cause the side wall to vibrate. For instance, this problem exists in varying degrees during the operation of the Shuifumiao, Centianhe and Huangtuxi hydropower stations. Therefore, as much as possible we should avoid opening the second side-hole by itself in the management of operation, or we should simultaneously open the first side-hole in order to control the lateral diffusion of the nappe of the second side-hole.

For hydrojunctions with half-bed discharge, a guide wall is often used to separate the spillway dam section and the power station to avoid waves, backflow and other effects of interference on the tail channel of the power station during discharge. Yet if the guide wall is made too long it will increase the cost of the project; and if it is too short, it will be difficult to improve the state of flow in the tail channel and will affect the output of the station. For instance, the guide wall of the Shuangpai Hydropower Station is merely 7.5 meters long and because of the flow hindrance of mounds during discharge of the large dam, when the water passes through the tail channel of the power station, it is deflected toward the left bank, thereby causing backflow and cross-gradient of the water in the tail channel.

The guide wall of the Centianhe Hydropower Station is 14 meters long, and a relatively large backflow had developed in the tail channel during discharge of the large dam. In order to improve the state of flow of the tail channel, an integral model test was undertaken in 1974 after the project was completed and schemes for extending the guide wall to 32, 48 and 64 meters were compared. The test clearly showed that the longer is the guide wall the better is the state of flow in the tail channel. When the guide wall was 48 meters long, the backflow velocity within the tail channel was reduced from 4.41 meters per second in the original scheme to about 0.4 meter per second and the depth of the scour hole was also less than the original scheme. The reason is that the distance between the nappe and the water contact point in the original scheme far exceeded the length of the guide wall. During discharge, water was compensated from the tail channel toward below the nappe through backflow, thereby increasing the flow of scouring. Therefore, from a hydrological point of view, the length of guide wall should be extended beyond the nappe water contact point. In this way, not only can the state of flow in the tail channel be improved, the effect of downstream bed deforming from scouring and silting can also be reduced.

(3) Hydrojunctions With Full-Bed Discharge

Although full-bed discharge projects are not endangered by direct impact of ski-jump nappe on the side wall of the power station, there is a possibility of backflow scouring of the foot of the side wall. For example, during flood discharge of the Zhexi large dam, a strong backflow is formed along the power station's retaining wall toward the lower bucket. The waste accumulated near the retaining wall is scoured and there is resilting in the lower bucket.

The layout of the Taohuajiang Reservoir is similar to that of the Zhexi Hydropower Station and the hydropower station is arranged on the platform of the left bank. During the flood discharge in August 1969, a strong backflow developed at the foot of the hydropower station and the area around the discharge lock, causing a scouring depth of more than 3 meters at the foot of the platform. Therefore the scour holes were dried up in the winter of 1970, a 3.65-meter high retaining wall was built and grouted rock slope protection was given to the platform on which the powerhouse stands.

3. Effect of Mounds on Output of Power Stations

(1) Downstream Scouring and Accumulation of Several Reservoirs

A shortcoming of ski-jump energy dissipation which cannot be ignored is that while scour holes are formed downstream from the dam, mounds and sand banks will be formed over a rather long distance downstream from the scour holes, which may block the tail channel of the hydropower station, affect the output of the hydropower station or affect navigation and log passage.

Based on the operation and experience of the Shuangpai, Huangtuxi, Centianhe and Fengtan projects, scour holes may form and mounds may be built up downstream one or two large floods after the project goes into operation. Mounds

in the model are of a hill shape and they are more level in the prototype, but the height of mounds compared to the depth of scour in the prototype may be as high as 0.6 to 0.8 (see Table 2). For the Ouyanghai arch dam which has a relatively high flow centripetal concentration, this ratio is as high as 1.0 to 1.2.

Based on the data of the projects listed in Table 2, the width of mounds is approximately 80 percent of the total bed width. Rock blocks on top of mounds are relatively large in size, mostly 1 to 2 meters and are square or rectangular shaped. Their size gradually decreases with the flow downstream, and mounds and sand banks generally extend very far downstream. For example, the mounds of the Shuangpai Hydropower Station rise 5 meters above the original bed and are as much as 400 meters long. If we go by the sand bank's actually measured gradient of 1/60 and extend it to the original elevation of the river bed, it would be as long as 700 meters, or equivalent to 13.5 times the height of the dam.

(2) Examples of the Effect of Downstream Accumulation on Power Stations

In 1978 the Fengtan Hydropower Station was basically completed and went into production of electricity. During the 5 years up to 1982, a total of 180,000 cubic meters of silt was accumulated in an area of 300 to 1,600 (equivalent to 14 times the height of the dam) meters downstream from the dam on the original foundation of the construction waste. The average height of the silt was 3 meters. Because the river bed was raised by silting, the tailwater level was also raised. According to the observations at the Fengtan Hydropower Station, during a flow of 300 cubic meters per second (when 3 generating units generate power), the tailwater level is raised by 4.0 to 5.1 meters as compared to the natural river before the construction of the reservoir (see Figure 5). The average annual loss of electric power output is approximately 4 percent of the design output.

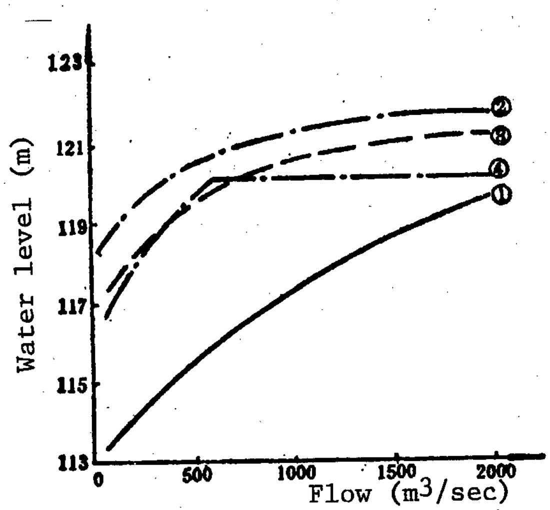

Figure 5. Tailwater Level-Flow Correlation Curve of the Fengtan Hydropower Station
1--Design curve; 2--Actually measured in 1978; 3--Actually measured in 1980; 4--Actually measured in 1982

Table 2. Downstream Scouring and Accumulation of Several Reservoirs

Name of project	Original elevation of river (meters)	Discharge (cubic meters per second)	Date of measurement	Maximum depth of scour t (below original bed elevation, in meters)	Maximum height of silt z (above original bed elevation, in meters)	t/z (%)	Loss in output of power generating units (%)	Percentage of silt in width of river bed	Remarks
Shuangpai	122.0	5,740	1961	9.91	7	71		78	Rockfilled over the years, later it silted again; mound built up to 125 meters wide and 400 meters long
Huangtuxi	152.0	1,043	7/1974 8/1980	5.2 9.4	4 7	77.0 74.5	About 10	80	Tail channel of power station cleaned annually, cross section 4 x 3 meters
Centianhe	218.0	1,040 2,060	1/1971 5/1972	2.75 7.0	1.45 4.0	64.5 57.0			
Ouyanghai	81.0	2,300	9/1971 6/1972	5.0 6.5	5.9 6.57	118 101			Secondary dam built 180 meters downstream in 3/1972, dam 16 meters high (11.5 meters above original bed)
Fengtan	107.0	10,780	8/1980	4.69	3 (average)	64	4	80	Average height of silt 3 meters, extending 1,600 meters downstream; Q = 300 cubic meters per second when 3 units generate power; water level raised by 4-5 meters

The river bed of the Huangtuxi Reservoir is relatively narrow, and because the bed on the left bank is higher and due to the effect of mounds, the downward discharge flow of the spillway dam is deflected to the 1/5-wide bed on the right bank, thereby accumulating large quantities of sand and rock around the flood control wall between the power station and the spillway dam, crushing a 10-meter end section of the wall and completely silting up the tail channel. At worst, the annual loss in power output is 10 percent.

Although the Shuifumiao Reservoir is of the wide river valley type, it also has the problem of intrusion of sand and rock into the tail channel of its power station. In order to prevent backflow and intrusion by sand and rock into the tail channel of the hydropower station, attempts have been made to lengthen and heighten the short weir. At present, the original guide wall and short jetty are together 349.70 meters long and the sand bank has been extended to over 600 meters downstream from the large dam..

In order to reduce the effect of silting on power generation and bed deformation, Hunan has combined the needs of the Shuangpai, Shuifumiao, Huangtuxi and Huangshidong projects by using beach rock blocks as construction materials in large quantities.

Apart from scouring, the major source of waste is the waste solids accumulated on the downstream river bed during construction. Therefore, prompt and proper treatment of waste solids during the construction period should be stressed by both design and construction staff.

4. Problem of Protection Downstream From the Arch Dam

Most arch dams are built across V-shaped or U-shaped river valleys whose side slopes are usually scoured when crest overflow is used, so that other than the complete rock structure and strong scour-resistance capacity in Hunan, protective and reinforcement measures are generally adopted for side slopes. In recent years, more and more projects in Hunan such as the Banjiang, Ouyanghai and Maoxi projects build an additional secondary dam downstream from the dam to increase the body of water for energy dissipation. [Some projects (such as the Huamuqiao arch dam) have a concrete barrier downstream.] Some projects do not build protection when the single-width flow of dam crest downward discharge is small (within 10 square meters per second). Based on the operation of some arch dams in Hunan, the following points deserve our attention:

(1) Installing Aprons Downstream at Foot of Arch Dams

Judging from the scouring of the toe of the Xiaolongtan and Dalongtan spillway arch dams, other than having particularly perfect rock bed, it is usually suitable to make short aprons for protection. The length of aprons should be determined by specific conditions, for example, 10 to 20 meters.

As for the elevation of aprons, it should control the maximum pressure of moving water P_d/γ (prototype) less than a 30-meter water column, or with the pressure distribution coefficient (ratio between the pressure of moving water P_d/γ and the distance X_0 along the direction of nappe jet flow) less than 1.0. The formula for the pressure of moving water P_d/γ is:

$$P_d/\gamma = (V_1 \sin\beta)^2/2g, \quad (2)$$

In the formula: V_1--impact velocity of nappe on bottom of apron;
β--angle of incidence of nappe entering water surface.

(2) Installing a Secondary Dam Downstream

A secondary dam is installed downstream of the Banjiang, Ouyanghai, Maoxi and Xiaolongtan arch dams in Hunan, which plays a fine role in preventing or reducing downstream scouring. For example, before the Ouyanghai arch dam installed a secondary dam, and in the model the main current of the ski-jump nappe pounded on the left side of the river where the logway was located and a strong backflow formed on the right side. In order to reduce erosion and to improve the temperature stress of the lower part of the dam, a 16-meter high secondary dam (11.5 meters counting from the bed) was built 180 meters downstream from the dam. After the secondary dam was built, the velocity distribution was reduced and regulated and the role it plays is notable.

On 19 October 1970, all 5 openings of the lock gates of the Ouyanghai arch dam were opened when the secondary dam had not been completed. The discharge flow was less than 2,300 cubic meters per second and the scour depth of the river bed was 5 meters. In March 1972 when construction of the secondary dam was completed, the discharge exceeded 2,000 cubic meters per second on 3 occasions and the depth of scour was basically stable around 6 meters while the elevation of accumulation in front of the secondary dam was merely 1.7 meters from the elevation of the secondary dam crest. Thus mounds will be built up when the flow is increased and the scour hole deepens. We have yet to observe whether the secondary dam's role of control will gradually disappear.

5. Effect of Discharge on Navigation and Log Passing

(1) Overview

Some of the key water conservancy projects in narrow river sections are responsible for navigation and log passing. Based on topographical and shipping conditions, measures are suited to local circumstances. Some use ship locks and logways and some use inclined ship lifts or hoists mounted on dam crests (see Table 3).

Navigation structures are generally arranged on the banks. Although they increase the complexity of project layout, they usually do not take up too much land and they do not cause major interference if the layout is proper. For example, the logway of the Centianhe Reservoir is arranged on the left side slope which has a large drop, a sharp gradient and allows a large log passage volume. After repeated tests and studies, movable steel channels are used for the inlet section to suit the variation in reservoir stages. Varied types of longitudinal slopes are often used for the mid-section of logway and rectangular teethed pits are installed to enhance roughness, and the mean velocity of the entire logway is controlled at around 5 meters per second. The outlet section is arranged in the deepwater areas of concave

Table 3. Navigation and Log Passing Facilities of Some Key Water Conservancy Projects in Hunan

Name of project	Navigation and log passing facilities	Upstream stage variation (meters)	Down-stream stage variation (meters)	Total drop (meters)	Tonnage of ship	Size of lock chamber (meters)	Total length of navigation channel (incl. approach channel, in meters)	Average gradient
Shuangpai	Single-line second stage lock	14	5.5	43	100-ton barge	8 x 56	570	
Centianhe	Water logway	10	6.7	34.25	Timber raft 6x17x1 meters	6.5 meters wide	598.4	1/10.72
Zhexi	Inclined ship lift	23.5	7.3	74.8	300-ton barge		1,430	1/6
Ouyanghai	Inclined ship lift	13.5	3.0	48.5	30		771	1/6
Fengtan	Vertical-inclined ship lift	35	3.16	90.8	50		815	1/7
Yanwutan	Dam crest hoist				5-ton hoisting capacity			
Shuifumiao	Single-line second stage lock	10.5	0	28	100 tons	21 x 56	246.5 (excluding approach channel)	

banks, and this helps logs to enter the river downstream smoothly. The type of logway outlet had been revised several times. Finally an extended fixed section (with a gradient of 1:12) was adopted all the way to below downstream tailwater level. Moreover, longitudinal slopes were adjusted and roughness was increased so that an undulating jump connection is maintained between the current at the outlet and highly variable downstream water surface. Conditions are fine through 13 years of actual operation and the operation of the prototype and model are basically similar. This logway is a living example of successful logway layout in narrow river valley, and it received a National Science Congress award in 1978.

The single-line second-stage lock in the Shuangpai hydrojunction is arranged on the relatively gentle rock slope on the left side of the hydropower station. A 185-meter long transition is set up between the upper and lower lock chambers. Not only does this fully utilize the terrain, reduce the volume of excavation and increase the lockage shipping capacity but it also keeps downstream navigation lanes far away from the ski-jump scoured area of the spillway dam. This reduces the threat of scouring and silting and thereby improves the flow conditions at the navigation outlet. Based on 20 years of operation, this type of layout is more economically rational.

(2) Effect of Discharge on Navigation and Log Passing

The normal operation of navigation structures is constantly affected by flood discharge, scouring and river deformation. The following conditions are frequent:

A. Deflected Currents Scour the Foot Stalls of Navigation Structures

Deflected currents pound on side slopes and endanger the foot stalls of navigation structures. For instance, when the Centianhe spillway dam discharged in its early phase, because the right bank mountain was protruding and solid, and because mounds rapidly formed downstream from the scour holes, water was deflected from the right to the left bank and the foot stalls of the logway bent on the left bank were scoured. Later, reinforcement and treatment safeguarded the normal operation of the logway.

B. Silting of Rivers Affects Navigation

Rivers deform as a result of silting, causing backflow near approach channels and affecting navigation. For instance, sand banks are formed downstream from the large dam of the Shuangpai Hydropower Station, which cause the main current to go left, consequently causing backflow in the tail channel of the hydropower plant and near the approach channel outlet as well as causing water surface movement. Therefore, apart from requiring the excavation of the approach channel and its outlet according to design, a diversion pier was added to improve conditions in the use of the approach channel.

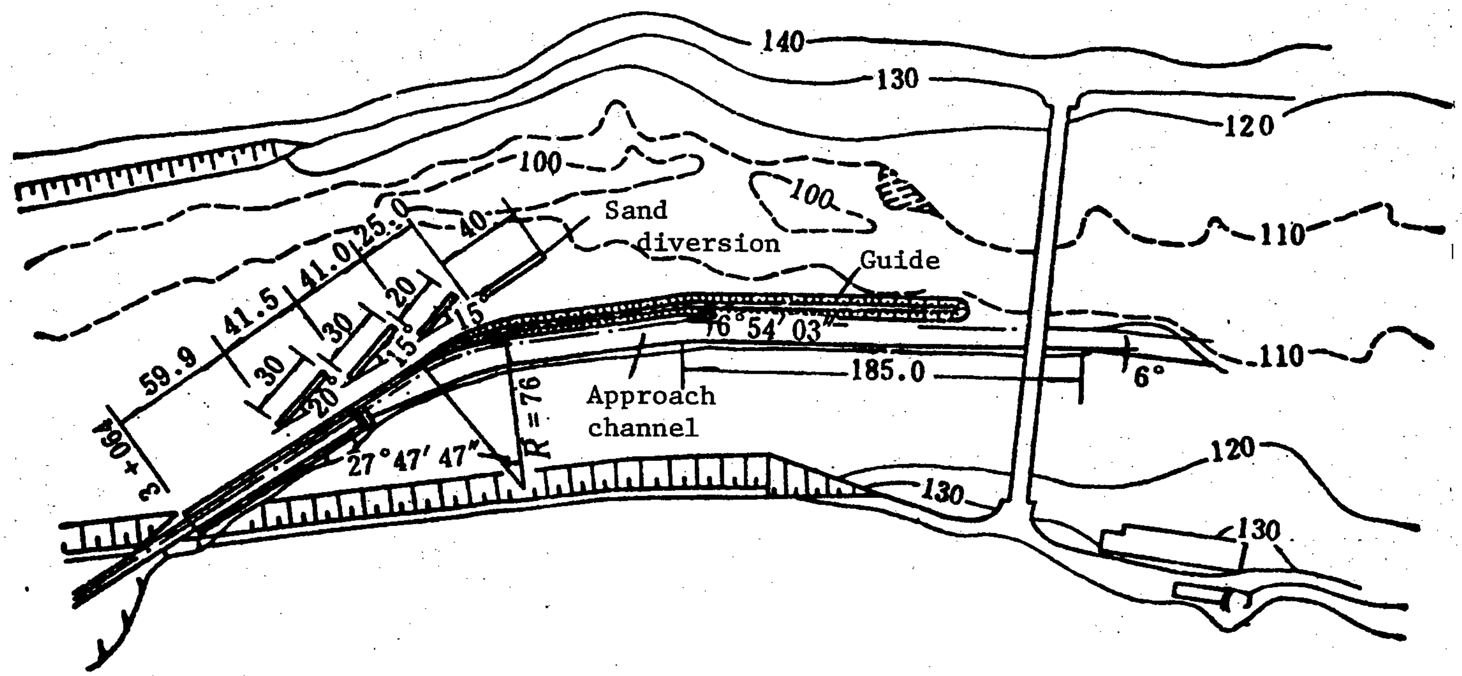

Figure 6. Plane Layout of Downstream Approach Channel of the Fengtan Hydropower Station

C. Intrusion of Sand Banks Into Approach Channels Affects Navigation

In the model test of the approach channel of the Fengtan Hydropower Station, large amounts of rock blocks accumulated in the downstream rivers during discharge of the spillway dam, crossed over the guiding jetty and silted up the approach channel. For this reason, 4 sand diversion pits were placed beyond the guide jetty to halt the intrusion of sand banks (see Figure 6).

Due to the relatively broken foundation rock of the Shuifumiao Reservoir and large silting downstream, not only has a lower jetty been added to the tail-water guide wall of the hydropower station several times, but a low jetty likewise has been added to the outside of the approach channel to block the intrusion of sand banks.

The above points clearly show that when we lay out navigation structures we must fully consider the interference and effects of discharge on downstream approach channels including the effects of deflection or direct impact, the effects of backflow or current movement as well as the effects of sand bank intrusion. The outlets of approach channels should be arranged in deep-water areas beyond those affected by scouring and silting as much as possible.

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HYDROPOWER

PLANNING OF CASCADE STATIONS ON THE MAOTIAO HE DETAILED

Beijing SHIULI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 9, 20 Sep 84 pp 13-19, 48

[Article by Guan Weiqing [4619 1919 1987]]

[Excerpts] The main development goal of the Maotiao He cascades is generation of electricity. The entire cascade consists of 6 hydropower stations and 14 generating units with a total capacity of 239,000 kilowatts. The project was completed between 1958 and 1979. The two upstream regulating reservoirs of Hongfeng and Baihua have such benefits of comprehensive utilization as irrigation, and in recent years tourism at the reservoirs has also developed somewhat. According to figures up to 1980, the Maotiao He cascade hydropower stations had transmitted 5.75 billion kilowatt-hours of electricity to the Guiyang area. Judging from the entire construction process of the cascade hydropower stations, under the prerequisite of central planning, the entire river went by the development program of going from high to low levels and has realized continuous cascade development. The planning of each cascade hydropower station took into account coordination between upstream and downstream hydropower stations so that some experience has been obtained. At the same time, some problems have arisen in the course of construction of the Maotiao He hydropower stations. I will now discuss some of the details and experience in the planning of the Maotiao He cascade based on my own knowledge.

I. Survey of the River Basin

1. Topographical features of the river

The Maotiao He is a tributary of the Wu Jiang within the provincial borders of Guizhou. It has two sources upstream. The left source is the Gouqiao He which originates from the Chang Shan in Anshun County while its right source is the Yangchang He which originates from the Ma'an Shan in Changshun County. Both sources converge near the Hongfeng Hydropower Station and then flow toward the northeast, passing through the two counties in Qingzhen and Xiuwen and empties into the Wu Jiang in Shapo. The river is 181 kilometers in length, controls a drainage area of 3,195 square kilometers and has a natural drop of 549.6 meters, a mean flow of 55.9 cubic meters per second. It is a medium-small river in central Guizhou (see Figure 1).

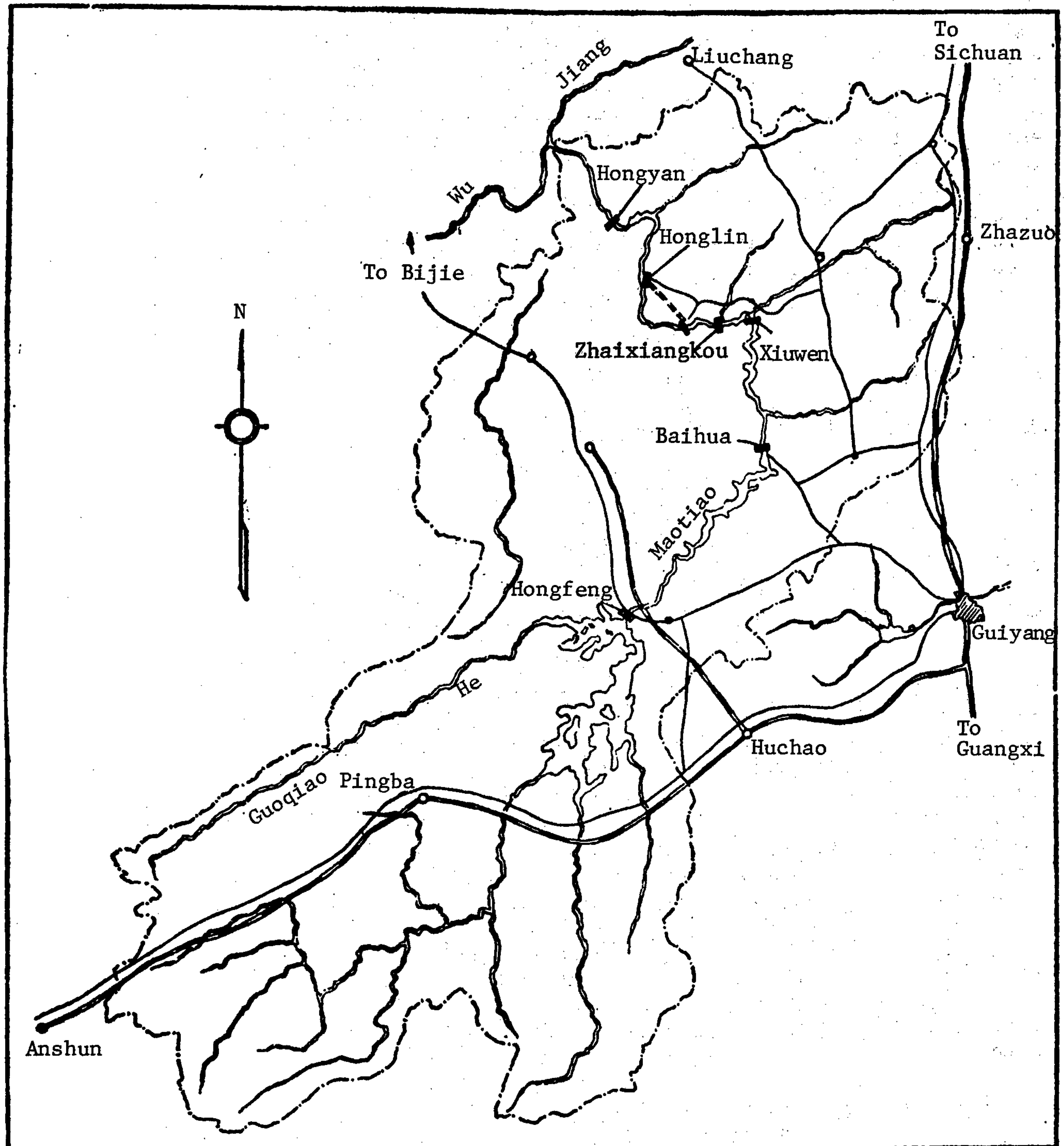

Figure 1. Schematic Locations of the Maotiao He River Basin and Cascade Hydropower Stations

The Maotiao He basin has an overall dumbbell shape, large at the two ends and small in the middle, and the area around the Hongfeng Hydropower Station slightly narrows. The controlled drainage area upstream from Hongfeng is 1,596 square kilometers, which constitutes 51.2 percent of the entire drainage area. The terrain is flat, the river drops are small and the mean gradient of the riverbed is 1.2 per 1,000. The midstream section is fron Hongfeng to Baihua where the riverbed gradient begins to increase to approximately 2 per 1,000. The downstream section is from Baihua. There the river cuts through high mountains and gorges. Both banks of the river are sparsely populated and are not easily accessible by transport. The river has many shoals and rapids and the riverbed gradient is as high as 7 per 1,000, which is the section of the river richest in hydropower resources. The characteristics of the Maotiao He differ from those of ordinary rivers in that its upper course is open and level while its lower course is narrow and deep, high and precipitous.

2. Hydrometeorological conditions

The hydrological data within the river basin is scanty. The hydrological station of the Xiuwen power station established in November 1943 is the survey station with the longest recorded hydrological data. This station controls a drainage area of 2,145 square kilometers and has kept data on the water level, flow, and rainfall since 1947. It is this station which formed the main basis for planning and design. The river basin is situated in the subtropical monsoon climatic zone and has an overyear average rainfall of approximately 1,300 millimeters. Rainfall is not evenly distributed within the year but is mostly concentrated in the months from May through September. The overyear average flow of the dam sites of the cascade hydropower stations is between 30 to 50 cubic meters per second and the annual runoff variation factor is approximately 0.26 to 0.28. There are a great many rainstorms in June and July in the river basin, most of which are 1-day rainstorms. Rainstorms take place mainly at night and are concentrated for 9 to 12 hours. According to calculations from actually observed data and figures, the 3-hour rainfall at the Wuliqiao Station on 27 June 1959 was 151 millimeters and the 12-hour rainfall at the Hongfeng Station on 10 July 1963 was 253 millimeters. The intensity of short-duration rainstorms in this river basin is therefore very high. Since the terrain of the river basin is complex and the confluence conditions of the different areas vary greatly, and moreover, because of the inordinate time-space distribution of the rainstorms, the flood hydrographs of this river basin are complex; there are hydrographs with double flood peaks as well as hydrographs with pointy, slender single peaks.

3. Geological conditions

The Yangchang He, which is the mainstream of the Maotiao He, is located at the northern edge of the sunken fault-fold in northern Guizhou. It is an area tightly lined with level and open synclines and narrow anticlines, where formations from the Devonian to the Jurassic are distributed, of which interbedding of Middle Triassic dolomite, dolomitic limestone, argillaceous limestone and shale are the most extensive. The karst is highly developed and in general it is not suitable to raise the reservoir retention level too high.

The midstream section from the Yangchang He to Wuliqiao is situated on the uplifted southern slope in central Guizhou and on the Guiyang-Pingba Fault. Its stratigraphic distribution is primarily Triassic and its hydrogeological and karst conditions are of multilayered aquifers. The water-bearing layers and confining layers are mutually formed and the karst is medium developed. This river section has the conditions for building large reservoirs and embankment-dam type of development. The river section downstream from Wuliqiao is situated on the uplifted Kaiyang fault-block in central Guizhou. Its formations consist of those from the Presinian Banxi group to the Lower Triassic, of which Middle and Upper Cambrian dolomite is the most extensively distributed. The shear fissures on both banks are developed and the border slopes are high and precipitous. Stability conditions are poor and construction of high dams in this river section would produce complex problems of karst seepage and engineering would be very difficult.

II. Cascade Development Plan and Installed Capacity Selection

1. Survey of cascade development plan

Based on the characteristics of the river as well as its topographical and geological conditions, the Maotiao He cascade power stations adopted the development plan of building regulating reservoir upstream and run-of-river hydropower stations downstream.

(1) River sections upstream from Baihua

The river valley of this section is open and has favorable topographical conditions for the construction of reservoirs. Moreover, in this area industry is concentrated, agriculture is developed, and there is a demand for water for industrial use and irrigation of farmland. Consequently, embankment-dam type of development was considered during planning. Today, the two large reservoirs of Hongfeng and Baihua have been constructed. Together they control a drainage area of 1,895 square kilometers, or 59.3 percent of the total area of the river basin. The two reservoirs have a total storage of 783 million cubic meters below the normal storage level and have good regulating performance.

The Hongfeng Reservoir is the key project of the entire river cascade development. The foundation of the large Hongfeng dam is primarily dolomitic limestone and is adequately stable and safe for a rockfill dam. Around the reservoir, most of the areas of the divide are of argillaceous limestone and limestone shales which generally slope upstream or into the reservoir. They have good confining function so that the reservoir has no seepage. Having taken into account the technical and economic argument of downstream cascade [development] and having considered avoiding the effects of flooding and immersion of the industrial districts of the two counties of Pingba and Qingzhen as well as the Yunnan-Guizhou Highway, the normal storage level of the Hongfeng Reservoir was finally selected at 1,240 meters, its dead water level was selected at 1,227.5 meters.

For the normal storage level of the Baihua Reservoir, after analysis and comparison the 1,195-meter scheme which links up with the Hongfeng Reservoir was chosen. Apart from its outstanding kinetic energy target, the reservoir flood regulating capacity of this plan is strong, which can more effectively reduce the reservoir peak flood in flow of the Xiuwen Hydropower Station. Under the prerequisite of taking into account the benefits of the kinetic energy of the cascade, the dead water level of the Baihua Reservoir was determined at 1,188 meters. Because the two reservoirs of Hongfeng and Baihua jointly regulate, the dry-year regulated flow of the Baihua Hydropower Station with an assured design ratio of 95 percent can be raised to more than 20 cubic meters per second, thereby solving the runoff regulation of the cascade hydropower stations.

(2) River section downstream from Baihua

Because of the limitations on this river section by topographical and geological conditions, the cascade development scheme considered in planning were all run-of-river hydropower stations with low reservoir capacity. The reservoirs are merely equipped with daily regulating function. Their development goal is unitary and there is no demand for comprehensive utilization other than the generation of electricity. The third cascade Xiuwen Hydropower Station utilizes a drop of 39 meters and is an embankment-dam. The fourth cascade Zhaixiangkou Hydropower Station utilizes a drop of 62 meters and is a combined type of development. The fifth cascade Honglin Hydropower Station adopts the diversion type of development with an installed capacity of 102,000 kilowatts and utilizes a drop of 146 meters, which constitutes 38 percent of the utilized drop of 384.5 meters of the Maotiao He cascade. The sixth cascade Hongyan Hydropower Station utilizes a drop of 49 meters and is a combined type of development whose tailwater links up with the Suofengying cascade, a mainstream of the Wu Jiang.

The water level of the four hydropower stations of Xiuwen, Zhaixiangkou, Honglin, and Hongyan are all capable of linking up both upstream and downstream. The exception is that there is still a 20.5-meter drop between the second cascade Baihua Hydropower Station and the third cascade Xiuwen Hydropower Station not yet utilized. The major reason is that owing to geological problems, the dam site of the second hydropower station had been moved from Xiaotunpo to Baihua. To make up for this drawback, the construction of a Baihua (downstream) hydropower station with an installed capacity of around 10,000 kilowatts is being planned. The longitudinal section of Maotiao He cascade development is shown in Figure 2; see Table 1 for the technical and economic targets of the various hydropower stations.

2. Selection of the cascade installed capacity

The following issues were considered in the selection of the installed capacity of the Maotiao He cascade hydropower stations.

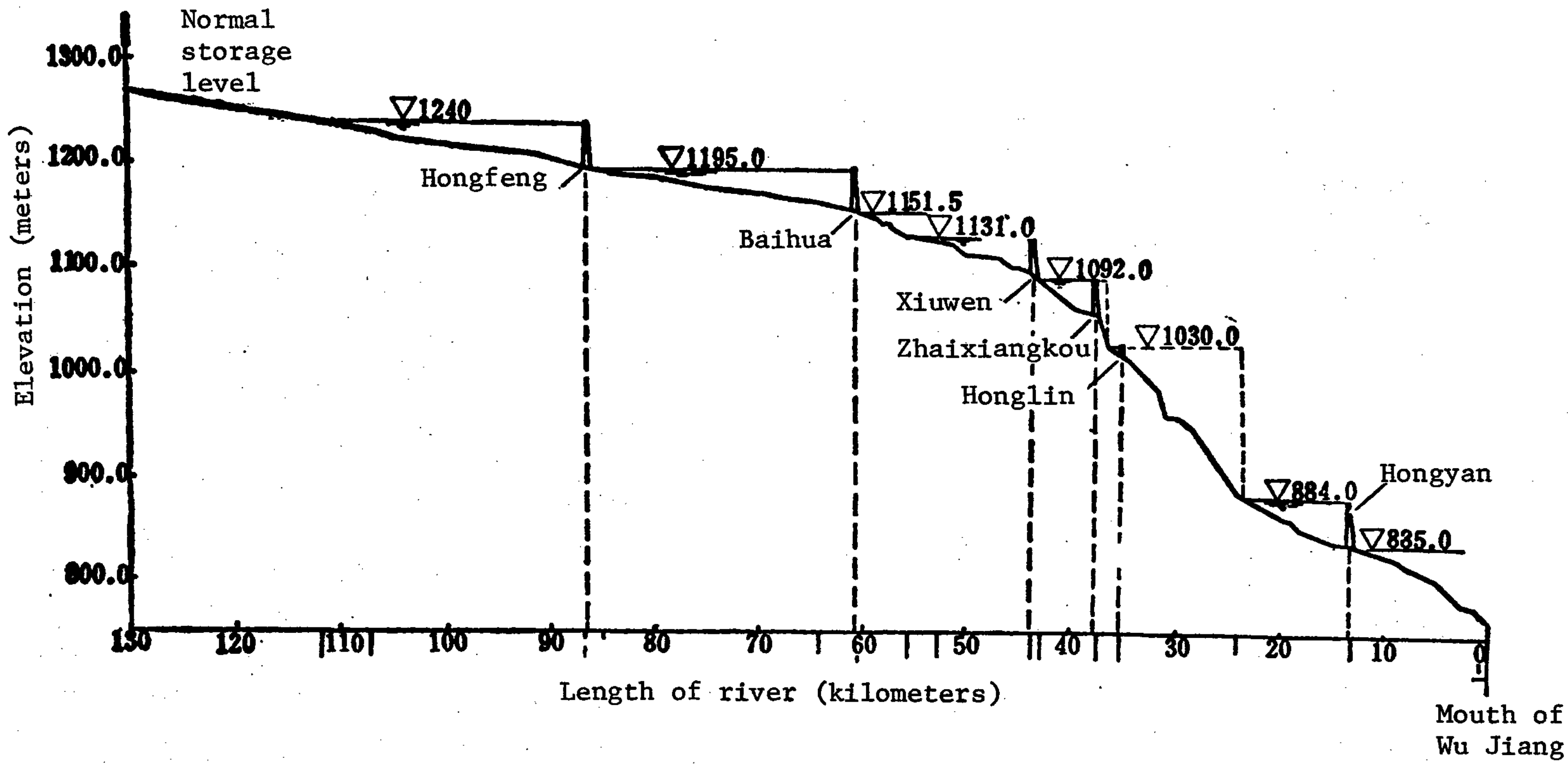

Figure 2. Schematic Longitudinal Section of Maotiao He Cascade Development

Table 1. Technical and Economic Targets of Maotiao He Cascade Hydropower Stations

Cascade Sequence Number	1	2	3	4	5	6	Total
Item:							
Name of power station	Hongfeng	Baihua	Xiuwen	Zhaixiangkou	Honglin	Hongyan	
Water catchment area (km^2)	1,596	1,895	2,145	2,424	2,442	2,792	
Overyear average flow (m^3/s)	30.2	36.0	41.2	44.9	44.9	49.4	
Normal water storage level (m)	1,240	1,195	1,131	1,092	1,030	884	
Dead water level (m)	1,227.5	1,188.0	1,120	1,082	1,026.5	876	
Total reservoir capacity (100 million m^3)	6.01	1.82	0.114	0.0708	0.00715	0.304	8.326
Reservoir regulation	Overyear	Annual	Daily	Daily	None	Daily	
Installed capacity (10,000 kW)	2	2.2	2	4.5	10.2	3	23.9
Guaranteed power output (10,000 kW)	0.49	0.558	0.556	1.07	2.57	0.945	6.189
Annual energy production (100 million kW)	0.689	0.804	0.819	1.612	3.83	1.43	9.184
Dam type	Rockfill dam with timber facing	Rockfill dam with reinforced concrete facing	Concrete single-arch dam	Concrete double-arch dam	Concrete gravity dam	Concrete double-curvature arch dam	
Maximum dam height (m)	52.5	48.7	49	54.77	27.6	60	
Project volume (10,000 m^3)							
Earth-rock	49.2	73.3	3.78	18.5	35.4	41.4	221.58
Concrete	5.54	6.67	4.97	10.5	14.0	9.5	51.18
Flood damage of farmland and land (mu)	33,069	13,676	41	20	0	168	46,974
Population displaced	15,812	7,975	2	0	0	73	23,682
Budgetary estimate of investment (10,000 yuan)	3,325	4,255	1,821	3,998	7,204	2,880	23,483
Year of completion	1960	1966	1961	1970	1979	1974	

(1) The essential capacity of the Maotiao He cascade hydropower stations was considered on the basis of the cascade as a whole.

Planning and design demand that the Maotiao He cascades supply power to the Guizhou power system and undertake the task of peak regulation in the system. The work capacity of each cascade power station is based on the total work capacity of the cascade and calculated according to the guaranteed power output ratio. Considering that the Maotiao He cascade hydropower stations are close to the power consumption center of Guiyang and that the upstream Hongfeng and Baihua reservoirs have adequate storage, it is therefore quite rational for the Maotiao He cascade hydropower stations to undertake the reserve capacity of the system. According to analysis, before the large hydropower stations in the system are constructed and go into production, the Maotiao He cascade hydropower stations can undertake a reserve capacity of 60,000 to 70,000 kilowatts. When medium-sized and large hydropower stations in the system are constructed and go into production, the peak regulating task of the Maotiao He cascade hydropower stations may be alleviated and their work capacity somewhat reduced, but as the reserve capacity of the system it can be suitably increased at that time. Therefore, in terms of the cascade as a whole, regardless of whether there is any input by large hydropower stations in the system, the necessary capacity of the Maotiao He cascade hydropower stations can be maintained at 200,000 kilowatts and above. The degree of utilization of the total installed capacity of the cascade can be as high as 90 percent. As a result, the ratio of duplicated capacity within the total installed capacity of the Maotiao He cascade is small. The reserve capacity of the various cascade hydropower stations was distributed on the basis of the total reserve capacity of the cascade according to their water head ratios.

(2) Diversion flow of upstream and downstream hydropower stations should be coordinated.

Because there is a hydraulic connection between upstream and downstream cascade hydropower stations, when selecting the installed capacity of the Maotiao He cascade hydropower stations attention was given to the question that diversion flow for power generation should be coordinated between upstream and downstream. The diversion flow of the Hongfeng, Baihua, and Xiuwen hydropower stations are 71.6, 74.2 and 71.6 cubic meters per second respectively. Consequently when Hongfeng is full and discharges water it will not cause the second and third cascade hydropower stations to discard water uselessly. Zhaixiangkou and Honglin are actually a group of hydropower stations. The fourth cascade tailwater is closely linked to the entrance to the fifth cascade power station and there is no interval runoff entering between them. Their diversion flow for power generation are 96.9 and 96.6 cubic meters per second respectively, which are higher than upstream power stations. The diversion flow for power generation of the sixth cascade Hongyan hydropower station was interfered with during planning. Its designed value at 77 cubic meters per second is notably small. Judging from the cascade as a whole, the discharge flow for power generation of most of the cascade hydropower stations of the Maotiao He are basically coordinated.

(3) Take into account the design results of electric power balance as well as the current supply conditions of generating units.

When the installed capacity of the Maotiao He cascade hydropower stations was finally determined, apart from considering the design results of electric power balance, current supply conditions of generating units were strongly taken into account and domestically manufactured units were applied indiscriminately. The purpose was to shorten the design period and speed up project construction. Take the Honglin Hydropower Station as an example. From electric and coulometric balance analysis, the capacity of the hydropower station was around 65,000 kilowatts and responsible for a reserve capacity of 25,000 kilowatts and the essential capacity of the power station should be around 90,000 kilowatts. Later it combined with the model of the Nanshui Hydropower Station and in the end three HL-638-LJ-200 generating units with a total capacity of 102,000 kilowatts were chosen to be installed.

(4) Reservoir capacity of daily regulated cascade hydropower stations must consider the effects of flow arrival time

The Maotiao He cascade downstream from the second cascade has only the daily regulated function. When the cascade operates in the system as a whole, the daily regulated reservoir capacity of all cascade hydropower stations must fulfill the demands of the types of operations considered in planning and must also take into consideration the effects produced by the flow arrival time and after retention. The key hydropower station of the Maotiao He cascade--the Honglin Hydropower Station--has a total reservoir capacity of 715,000 cubic meters and does not have its own regulating function. It adopts the operation which is totally synchronous with the upstream Zhaixiangkou Hydropower Station. Its needed daily regulated reservoir capacity is undertaken by upstream power stations so that this requires consideration of the effects of flow arrival time and after retention.

In short, the selection of the installed capacity of the Maotiao He cascade hydropower stations is sound and the arrangement for them to undertake peak regulation and emergency in the power system is realistic. With the exception of the sixth hydropower station which is small in installed capacity and has a long utilization time, the utilization time of the generating units of the first to the fifth hydropower station being around 3,500 to 4,000 hours is suitable. But it should be pointed out that among the Maotiao He cascade power stations, with the exception of fourth and fifth hydropower stations which adopt three generating units each, all the other power stations use two units and it has been discovered after actual operation that the scheme of two generating units is not favorable to the control of cascade operations.

III. Cascade Design Flood and Flood Control Planning

1. Design flood analysis

Although the river basin is small in area, its hydrologic conditions are very complex, and since actually measured flow data being short in series and poor in quality, computation of design flood directly based on flow has

been made highly difficult. In order to increase the accuracy in computing design floods, other than using flow data, rainfall data is fully utilized to calculate design floods through design rainstorm.

(1) Computing design flood on the basis of flow data

This is primarily used to analyze the design flood in the river basin upstream from Hongfeng, but flood-frequency computations have also been made for the interval between Hongfeng and Xiuwen, the hydrologic station of the Xiuwen power plant, and the Shizishi hydrologic station.

(2) Computing design flood on the basis of rainstorm data

A. Spot rainfall frequency analysis

In order to reduce accidental errors caused by extraordinary values during single station analysis, the Maotiao He river basin has adopted the "mean" value method area synthesis" to analyze the statistical law of spot rainfall. That is, selecting representative experienced frequency points at the seven stations of Luoping, Pingzhai, Erguanzhai, Pingba, Hongfeng, Baihua, and Shizishi, to be drawn on the same frequency chart and obtaining the mean value of spot rainfall with the same frequency at the seven stations as the rainfall series of the representative points in the river basin, whereby visually estimated approximate graph in order to calculate the design value of each frequency. The highest representative 1-day mean rainfall value of the Maotiao He river basin is 101 millimeters for which the C_v value is 0.52 and C_s/C_v gives 3.5; the greatest 3-day mean rainfall value is 136 millimeters for which the C_v value is 0.46 and C_s/C_v gives 3.5.

B. Area rainfall frequency analysis

In order to strengthen the representative property of the actually surveyed area rainfall series, extraordinary values were processed for strong rainstorm that had already taken place in the design river basin at the time when area rainfall frequency was calculated. For example, for the "63.7" rainstorm, its recurrence period of 50 years was used in frequency computation after analysis and demonstration. When data on large rainstorms are insufficient in the series, consideration was given to shifting to the area rainstorm data of neighboring river basins. For instance, for the river basin upstream from Hongfeng, the shift was made to the "70.7" rainstorm of the neighboring Qingshui Jiang river basin at the time of computation while it was demonstrated that its recurrence period could be determined at 200 years. The representative property of the area rainfall series was strengthened after the above processing, and the frequency computation results as examined in the river basin area were also relatively rational. Together with frequency point-area relations it conforms to the general law of decreasing along with the increase in the area of the river basin. Moreover, it is close to the average conditions of the point-area relations of several actually measured large rainstorms. Consequently, the results could be used as the basis of design.

C. Convergence computation

The deduction method was adopted, and it was assumed that the earlier stage moisture index under the conditions of design rainstorm was similar to the actual large rainstorm model. For the computation for the river basin upstream from Hongfeng, unitary hydrographs which take into account in flow effects and nonlinear changes of unconsidered unitary hydrographs were adopted. For the concentration computation of the two intervals and drainage area from Hongfeng to Xiuwen and from Baihua to Xiuwen, unitary hydrographs which take into account nonlinear changes were adopted.

D. Design flood analysis of intervals downstream from Hongfeng

In light of the conditions of data on the Maotiao He as well as the characteristic that the area of each interval was small, the design flood of each interval was computed by the inference formula method in addition to the unitary hydrograph method. After comparison and analysis, the results of the inference formula method were at the end chosen to carry out area synthesis. According to analysis of actual data, the design flood peak flow Q_p of all intervals of the Maotiao He has the following experience of relationship with river basin area F:

$$Q_p = K_p F^{0.71}, \qquad (1)$$

In the formula, K_p is the parameter related to the recurrence interval. In the Maotiao He area one gets 24.3 for a recurrence interval of 50 years, 28.3 for 100 years, 32.8 for 200 years and 77.6 for 500 years.

To summarize the above, the design flood of the Maotiao He cascade adopted diverse ways of analysis and utilized design results obtained by various methods to verify each other. For the design flood of the river basin upstream from Hongfeng, the results of the flow method and the rainstorm method are close. Therefore, results from the rainstorm method were adopted in the flood regulation and flood control planning of the Maotiao He cascade.

2. Flood control planning

There are no major cities and towns or residential communities along the Maotiao He, and there are no large areas of farmland that need protection. The main substance of the flood control planning of cascade reservoirs is selecting the sizes of flood discharge works and studying their operation in order to guarantee the safety of the cascade hydropower stations themselves.

(1) Design standards

The two regulating reservoirs upstream of the Maotiao He cascade are key projects for the flood control safety of the entire cascade. In order to prevent chain reaction after an accident, the two reservoirs should have adequate flood resistance capability. According to stipulated standards, the two reservoirs of Hongfeng and Baihua are of grade II engineering, and the safety

of large dams are based on class II structure design. Their design standards of extraordinary use has been chosen to be once every 10,000 years. At the time of planning, the standards of extraordinary use selected for the hydropower stations downstream from Baihua were once every 500 years for the fourth and fifth cascades and once every 200 years for the third and sixth. Comparing the requirements of their standards, the check standards of the third and sixth hydropower stations are lower. The reservoir capacity of the hydropower stations downstream from Baihua is smaller and design flood can be considered according to peaks. Because at the time of planning consideration was given to the two reservoirs of Hongfeng and Baihua to control floods upstream and the two reservoirs were required to close their gates and completely stagger flood peaks in downstream intervals, the flood discharge works of the various cascades of hydropower stations downstream from Baihua can be designed according to the design flow peak in the area of intervals downstream from Baihua.

(2) Composition of flood areas

In view of the requirement on the two upstream reservoirs for flood storage and peak staggering by the cascade flood control planning, it was therefore necessary to make an in-depth analysis of the composition of the cascade flood areas. Based on the statistics of actual data of the Maotiao He, it was found that two typical situations must be considered during flood control planning. The first type of situation involves the rainstorm center being closer to upstream, the amount of water upstream from Hongfeng is very large and correspondingly the inflow of water into the interval is small. Moreover, along with the shift in the rainstorm center from upstream to downstream, the flood peaks in intervals may appear sooner than those upstream from Hongfeng. Although this is not critical for peak staggering in this type of area composition, this is not an advantageous model because of the volume control of the two reservoirs of Hongfeng and Baihua. The second type of situation involves the rainstorm center being concentrated in the intervals downstream from Hongfeng where flood peaks are high and large in volume, and moreover, free peak staggering does not exist upstream and downstream. These two types of flood area composition were respectively studied in flood regulation and flood control planning.

(3) Cascade flood regulation

Taking the cascade as a whole, joint routing was undertaken for the first, second and third stage reservoirs and the scheme for flood discharge works was rationally selected. All comparative schemes adopted similar form of peak staggering and regulation. The actually measured rainfall in the intervals is used as the signal for gate closing and peak staggering for the two reservoirs of Hongfeng and Baihua. The duration for peak staggering is 18 hours for Hongfeng and 12 hours for Baihua, but both are required not to exceed their own specified water level. For the opening of gates after gate closing and peak staggering, both reservoirs are controlled by their water levels as the norms. Because the design standards are low for the third hydropower station and its flood discharge capability is small, when the final scheme of flood discharge works was selected for the two reservoirs of Hongfeng and Baihua, their flood discharge volume was reduced in consideration of the flood control safety of the downstream Xiuwen power station.

IV. Cascade Development Program Arrangement and Comprehensive Utilization

1. Development program arrangement

The development of the Maotiao He cascade hydropower stations adopted the policy of building regulating reservoirs before run-of-river power stations and construction by stages from high to low levels. Because of the emphasis given to the construction of upstream regulating reservoirs, downstream run-of-river hydropower stations were prevented from operating by themselves without safeguard of runoff regulation, thereby greatly improving the results of power generation. Moreover, during flood control planning, consideration was given to upstream regulating reservoirs to undertake peak staggering and regulation of downstream cascade, it greatly reduces the design peak flow of downstream hydropower stations which is advantageous to simplifying the hydraulic arrangement of downstream hydropower stations and lowering construction costs. Building upstream regulating reservoirs first is also beneficial to reducing the construction of diversion flow of downstream hydropower stations and making diversion construction less difficult thereby enabling construction to speed up. The diversion closure of the second, third, fourth and fifth hydropower stations as well as the sixth cascade hydropower station longitudinal coffee crib caisson work were completed by taking advantage of equipment shutdown of upstream hydropower stations.

Construction of storage reservoirs would inevitably lead to great flood damage. For instance, the Hongfeng Reservoir flooded a total of approximately 33,000 mu of land and displaced a population of approximately 15,800 people. Flood damage is high in terms of a single reservoir, but the benefits of power generation and of comprehensive utilization it brings to the cascade as a whole are very notable.

2. Comprehensive utilization

Although the primary goal of Maotiao He cascade development is the generation of electricity, benefits of comprehensive utilization were taken into account during the planning and design of the two upstream Hongfeng and Baihua reservoirs. Judging from the operation of the reservoirs after they were constructed, the question of comprehensive utilization cannot be ignored in river planning and design.

(1) Irrigation

There is a demand for irrigation in the upstream area of the Maotiao He. Near a creek 2.5 kilometers northwest of the Hongfeng Hydropower Station, a large creek waterlifting and irrigation station has been built. This station consists of two waterlifting stages with a total design elevation of 67 meters and a design waterlifting flow of 3.52 cubic meters per second. Currently its actual irrigation area is over 20,000 mu. Apart from creek waterlifting and irrigation stations, the two counties of Qingzhen and Pingba have also built more than 10 small waterlifting and irrigation stations around the reservoir, and their total irrigated area is roughly equivalent to that of the creek waterlifting and irrigation station.

(2) Industrial water supply

The Guizhou area has high mountains and low rivers, and suitable industrial factory sites often lack assurance of a source of water. After the two storage reservoirs of Hongfeng and Baihua on the Maotiao He were constructed, metallurgical, light and industrial, chemical fertilizer, vinylon and thermal power plants and other industrial enterprises sprang up around the reservoirs. The industrial diversion flow of the two reservoirs have reached approximately 7 cubic meters per second. Although the task of industrial supply of water was understood in the planning of the Maotiao He cascade, reliability as demanded by industrial water supply was underestimated. During the construction of the large dam of the Hongfeng Reservoir in 1958, because steel materials and cement were in short supply, timber facing was boldly adopted in the design as the seepage prevention measure of the rockfill dam. After many years of operation, the timber facing has long exceeded its design period of use and there is an urgent need to replace it in order to assure the safety of the large dam. But because the various large industrial enterprises which obtain water from the Hongfeng Reservoir have already occupied an important place in the industrial output value of Guizhou Province, if the water supply from the reservoir is ever cut off, the factories will be forced to stop production. For some major chemical industrial enterprises, a halt in production will also cause problems of equipment cleaning and maintenance, so that the effects will be very profound. This fact tells us that the issue of industrial water supply from reservoirs need to be studied very carefully during river planning.

(3) Tourism

The two reservoirs of Hongfeng and Baihua on the Maotiao He have an extensive water surface area. The scenery is attractive, and they are excellent places for the laboring people to visit and take rests and for developing water sports. Hongfeng Hu is 30 kilometers from the provincial capital city of Guiyang. There are good transport facilities and excellent conditions for developing tourism. Along with the constant increase in the people's standard of living, it can be anticipated that tourism at the two reservoirs of the Maotiao He will further develop.

V. Some Points of Understanding

In summarizing the experience in the planning and design of the Maotiao He cascade, I have the following points of personal understanding.

1. In carrying out continuous cascade development of a river, first of all it requires that we have an overall point of view in river planning and design. We should treat the entire cascade as an entity and we cannot consider the planning and design of a particular power station in isolation. In the selection of design flood analysis, flood regulation, flood control planning and the design factors of hydropower stations for the various stages of the Maotiao He cascade, some characteristics of the cascade hydropower stations were taken into account and this was a correct way to do it.

2. Hydrological and geological data are the foundation of planning and design and we must first stress doing a good job on them. The hydrological data on the Maotiao He is scanty and poor in quality, which had caused considerable difficulty in planning and design work. Since it takes a certain amount of time to accumulate hydrological data, hydrological exploration surveys should be based on the strategic program of the river planning and arranged without delay. At the same time, we should require geological surveys of the stages in river planning to be made at a certain level of quality. The moving of the dam site of the second cascade hydropower station of the Maotiao He from Xiaotunpo to Baihua due to geological problems which caused a 20.5-meter drop between the Baihua Hydropower Station and downstream Xiuwen Hydropower Station to be unused must be taken as a lesson.

3. We must stress the study of the development program. When an upstream plan includes reservoirs with good regulating function, it is beneficial to realize continuous development from high to low levels. Improper handling of the development program may cause some problems in the course of project construction. For instance, for the third cascade Xiuwen Hydropower Station of the Maotiao He, the plan required the arrangement for it to go into production after the first and second stage reservoirs are constructed, but actually the third stage was completed earlier than the second stage. In July 1963 there was a rainstorm flood on the Maotiao He and a peak flow of 1,700 cubic meters per second was produced between Hongfeng and Xiuwen which exceeded the designed flow (1,520 cubic meters per second) of the Xiuwen Hydropower Station. Without the Baihua Reservoir to retain the flood and stagger the peak, it resulted in the front water level of the Xiuwen Hydropower Station dam to exceed the top of dam by 1.32 meters and caused an overflow. Fortunately it did not create a serious accident. This lesson tells us that cascade development program not only concerns the amount of economic benefits but sometimes it may even affect the safety of the project.

4. Cascade regulating reservoirs should be built without delay when population relocation and resettlement can be implemented. China has a large population and does not have an abundant land resource. In the future, along with the natural growth of the population and the development of industrial and agricultural production, land resource will become increasingly valuable and relocating and resettling people will also become increasingly difficult. All this will not favor the construction of large storage projects. Construction of the two regulating reservoirs of Hongfeng and Baihua was stressed in the early stage of the Maotiao He cascade development, which has given play to the benefits of the cascade.

5. During planning and design, we must not only take into account the benefits brought by the comprehensive utilization of reservoirs but we must also pay attention to the effects on the project construction itself brought about by the requirements of comprehensive utilization. Although the benefits of comprehensive utilization of the Hongfeng Reservoir of the Maotiao He are notable, the demand for industrial water supply which made it impossible for the large dam to examine and repair its timber facing on schedule is an example that deserves attention.

6. The responsibility for the planning and design of a river is best undertaken by a single exploration survey and design unit. This method of division of work based on rivers can enable various tasks to be carried out with planning and in steps; avoid unnecessary duplicated labor and increase work efficiency; easily coordinate to deal with different contradictions arisen in work; and easily centralize the mentality of planning. The experience of the Maotiao He planning and design has also proved that this is an effective work method.

7. When the installed capacity of each Maotiao He cascade hydropower station was finally determined, too often were generating units indiscriminately used. This was perhaps one solution to the problem when generating units were in short supply or when there was an urgency of time, but this should not be encouraged in the future. Hydropower stations differ from thermal power stations in that they are limited by ever changing natural conditions. In order to fully utilize natural resources, generating units ought to suit the construction of power stations.

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COMPUTER APPLICATIONS IN WATER CONSERVANCY AND HYDROPOWER ENGINEERING

Beijing SHUILI SHUIDIAN JISHU [WATER RESOURCES AND HYDROPOWER ENGINEERING] in Chinese No 9, 20 Sep 84 pp 25-30

[Article by Chen Jiming [7115 7139 2494]]

[Excerpts] I. Survey of Computer Applications

The use of computers in China's water conservancy and hydropower construction began in the 1960's. This was not a late start, and currently computers have been popularized and used in exploration surveys, planning, design, construction, operation, and scientific research. Considerable results have been achieved but their development among different professions is not balanced. For many years, various units have successively equipped themselves with a number of medium-small computers and microcomputers and have developed a number of application programs. Moreover, units concerned have convened a series of meetings on computer applications and operated hundreds of training classes on computer applications such as classes on hydraulic structure computation, finite elements, programming, different languages and equipment maintenance. Today an electronic computation contingent with almost 1,000 people has been formed. The application of computers in some of the key specialties in China's water conservancy and hydropower construction are as follows:

1. Use of computers in the planning and design of water conservancy and hydropower projects

Computers were used earliest and most extensively in China's water conservancy and hydropower construction in the scientific computation and data processing of engineering planning and design. Today it has made definite progress in depth and in scope, accumulated experience and has laid a good foundation for further popularization and use of computers in the future. The major areas in which computers are currently used include: processing and reorganization of hydrological data; computation and design in water conservancy and hydropower planning; computation of various types of hydraulic structures such as earth-rock dams, gravity dams, arch dams and lightweight dams; computation of various types of metallic structures such as arch gates, plate gates, metallic spiral casings; computation of factory structures, tunnels, pipelines and lock gates; computation of hydraulics, kinetic energy analysis, temperature and

creep stress computation, and complex computation of foundations (foundations with joints, crevasses, faults and fragmentation bands). In short, computers have been in use for computations in problems involving large numbers of calculations. Moreover, we have been able to use optimum models of computers in some areas such as gravity dams, arch dams and gates. New mathematical models or theories have been adopted to develop some programs, and advanced standards have been reached.

For many years, the use of computers has basically replaced manual calculations in some tedious computation tasks in the planning and design of water conservancy and hydropower projects. For the arch dam test load method, for instance, it would take about 12 man-months to complete a scheme by manual calculation while it would only take a computer 10 minutes to 1 hour or so and it would only take half a day even if one includes the preliminary work. This no longer causes fear in the design staff to undertake arch dam calculations but has greatly benefited the popularization and use of such a type of dam as the arch dam. As another example, temperature and creep stress computations of concrete dams are extremely tedious. In the past they basically could not be undertaken but a great deal of time can be saved when computers are used, making this type of computations possible. Besides, because computers have very high computation speed, comparison of multiple schemes can be carried out and different complicated factors can be taken into account thereby the quality of design can be greatly enhanced. For example, problems of analyzing stress and stability of high dams built on complex foundations (which consist of fault, fragmentation bands and weak intercalated beds) could only be very roughly estimated by approximate assumption in the past, but with computer analysis we can now use the nonlinear finite element method which can consider and reflect the actual conditions of the foundations as well as different factors, and carry out relatively more accurate computation and analysis thereby making computation results more conformed to reality. Consequently, design staff will have more confidence in the actual safety of structures and the repair of damaged equipment and can adopt more effective measures of handling. This assures the quality of design and makes it safe, economical and reliable. In short, the application of computers has saved a great deal of manpower and speeded up planning and design. Moreover, it is accurate and careful, which enhances the quality of planning and design.

2. Use of computers in the construction of water conservancy and hydropower projects

The use of an advanced tool such as the computer to carry out modern scientific management of water conservancy and hydropower engineering construction is an important measure to speed up water conservancy and hydropower construction and to improve economic results. At present, an excellent start has already been made in using microcomputers in water conservancy and hydropower engineering construction and management. Numerous units have drawn up microcomputer programs for various types of construction management which are being used in projects. For instance, the scientific research institute of the No 12 Engineering Bureau of the Ministry of Water Resources and Electric Power has used two microcomputers to do some exploratory work in the

management of planning and quality control as well as different types of information management system in water conservancy and hydropower engineering construction. Preliminary results have made it clear that by adopting microcomputers suitable for use at work sites it is entirely possible to bring about a new situation in the construction management of water conservancy and hydropower projects. In using the TRS-80 microcomputer for the quality control of concrete in water conservancy and hydropower engineering construction, the institute imported and developed some application programs such as data document management, correlational analysis, multivariate linear regression, primary regression orthogonal design and concrete design, solved cement strength forecasting which was formerly difficult to solve--utilization of strengthened cement, concrete design, data management and processing of concrete in construction; and drew selectively-controlled and fully-controlled joint concrete quality control diagnostic diagrams. In the area of cement strength forecasting, by using the microcomputer's data document management, correlational analysis and multivariate regression analysis programs they can speedily calculate forecast values. According to the figures, using this method under an assurance ratio of 97.7 percent, up to 70 to 80 strength marks can be used for the cement produced by plants with basically stable production techniques. This can assure the quality of concrete and can save 8 to 20 percent of the cement. In concrete design, they used microcomputers to calculate and print out a set of concrete gradation which only took several minutes and gave very notable results. As another example, in its recent construction work the Chang Jiang Gezhouba Engineering Bureau also used computers to manage its concrete batch plant, studied and experimented automatic control feeding, proportional mixing, weighing and tabulating. Judging from the trial operations, computerized management can improve work efficiency and assure the quality of concrete.

Application of computers in the management of worksite material systems is also an important way to realize modern management in the construction of water conservancy and hydropower projects. For example, the Chang Jiang Gezhouba Engineering Bureau in launching the study and experiments on material and warehouse management by computers, not only can the daily inflow and outflow of materials be managed and calculated by computers and facilitates inventory to be known at any time, more importantly computers can also forecast on the demand and supply, facilitate material preparation and feeding and make it possible to keep the most rational inventory of different types of materials. This makes close coordination possible, satisfies the needs of the construction of projects, makes the use of funds more rational and avoids waste created by overstocking.

3. Use of computers in operational management in water conservancy and hydropower projects

Experiments of automatic control in operational management of hydropower stations began as far back as the early 1970's. These included the Liuxihe Hydropower Station which used computers for closed-loop control of generating units and the Changshou Hydropower Station which carried out cascade centralized control. But results were not substantial because of the poor performance

of China-made minicomputers at that time. Later, the DJS-100 series of minicomputers were used at hydropower stations on the Xin'an Jiang, Fuchun Jiang, and Jingbo Hu for safety monitoring of generating units, centralized control and flood forecast dispatch which proved to be effective. For example, at the Fuchun Jiang Hydropower Station short-duration flood forecast and reservoir control stressed generating more power at flood peaks, and between 1975 and 1977 an additional 70 million kilowatt-hours were generated and the results were notable. Today, its application in larger hydropower stations is being studied. Moreover, the small tidal hydropower stations on the Liu He in Jiangsu replaced manual operations by microcomputers so that two 75,000-kilowatt turbine generators can open automatically. They are also used in control acceleration, voltage and frequency and to merge with power grids. At the same time, they can control the most optimum operation of the turbine generators according to the water level.

It is far easier to use computers to control operational management of hydropower stations than thermal power stations, and it can also greatly improve the levels of safety and economic operation of hydropower stations and systems, carry out actual-time data processing and control, reduce the number of operators and give impetus to the automation of hydropower stations. In the future, along with the constant increase in the capacity of hydropower stations and the increasing importance of the role of hydropower stations in systems, computers will certainly be further popularized and used in this area.

4. Use of computers in water conservancy and hydropower S&T information

S&T information work is an important component of S&T and information work. There is an urgent need for S&T information in carrying out water conservancy and hydropower construction, improving economic results and realizing the four modernizations. In order to speed up the realization of modern water conservancy and hydropower S&T information work, with the Institute of S&T Information of the Ministry of Water Resources and Electric Power as the center, it will fully utilize the existing international on-line information computer retrieval terminals, link up with various river agencies and power grid bureaus in a planned way, gradually establish a water conservancy and power S&T information computer checking system and realize domestic and overseas on-line information retrieval. Concerning the existing international on-line information retrieval terminal, it is a computer terminal linked with the information retrieval system of the European Space Agency which was installed by the ministry's Institute of S&T Information with the assistance of departments concerned at the end of 1983. In March this year, this terminal was also linked up with the DIALOG information system of the United States, and currently it has formally begun to supply on-line information retrieval service to units in the system of the ministry and to users in systems outside the ministry. At present, unrestricted by national boundaries and geographical locations, one is only required to sit in front of the monitor screen and operate the keyboard to find the needed data or clues to literature and sources from hundreds of data banks and hundreds of thousands of articles from the international on-line information retrieval system within approximately 10 minutes by means of man-machine dialog.

Since the founding of the state, China has constructed over 80,000 small and medium-sized reservoirs and hydropower stations and has accumulated abundant experience and extremely useful data. However, the amount of data is considerable and it makes checking highly inconvenient so that for a long period of time after that this valuable experience and data had not been fully utilized in water conservancy and hydropower construction. Today, combining with actual needs, the ministry's Water Conservancy and Hydropower Construction General Bureau is organizing its forces to use computers to build engineering data banks and carry out various tasks of engineering data retrieval. This will make it convenient to look up different data needed for use by the quarters concerned.

5. Use of computers in routine management

In recent years, we have already begun to popularize and use computers in routine management of water conservancy and hydropower construction such as wage management, material and warehouse management, management of staff and workers contingents and financial investment management. At present, various types of reports of the ministry's Water Conservancy and Hydropower Construction General Bureau and some engineering bureaus include details on the completion of project volumes, details on the use of materials and funds, and details on the use of machinery and equipment and the control of their repair and maintenance. Some of the data of these reports are tedious. Some are recorded daily, which wastes manpower and errors are easily caused. When the management system of different types of data and information is set up, it will be possible to have computers accurately and conveniently work out different kinds of reports and to preserve all the data in computers, and one will be able to freely transfer the data for a particular day or month for analysis and study so that leaders can scientifically direct production.

II. Weaknesses and Disparities in Computer Applications

In our computer applications since the founding of the state, although we started out with nothing and have built an enterprise through arduous effort and have achieved some results, for various reasons our level of computer application is still very low and there is a great disparity between ours and the advanced levels abroad. This is also a main reason why our water conservancy and hydropower construction is below the advanced levels abroad. At present, there is a new technological revolution in the world. If we do not pay serious attention to it and vigorously catch up, the disparity will increase. This is a very serious problem.

Our weaknesses and disparities are mainly manifested in the following areas:

1. Backward computer hardware

So far the Institute of Water Conservancy and Hydropower Design directly under the Ministry of Water Resources and Electric Power has not been equipped with a large computer which has good performance and powerful functions. Only a minority of the design institutes have some small and medium-sized machines produced by China in the 1970's. These machines are small in capacity and

slow in speed. Their system software is poor, operation is unstable and peripheral equipment is not complete, which are far from being able to satisfy the needs in solving large problems. In order to solve a problem using the computer, the design staff frequently has to seek assistance by traveling throughout the country, which consumes a great deal of manpower, time and money. In this way the application of computers naturally become highly limited.

Since hardware is not good in quality, the development of software is no doubt also seriously affected. The use of computers to aid design and improve design, and for enterprise management and data processing and retrieval is even more limited.

2. Divided strength, duplication and waste

Although the water conservation and hydropower system is already in possession of a number of application programs with a total of more than 400, it lacks an effective organization and work relating to software has not been given the attention it deserves. Frequently strength is divided, everyone fights his own battle and each has his own emphasis. Many tasks are performed at a poor level with duplication and waste, and frequently no one is able to come up with a perfect and outstanding application program for some complex problems urgently needed to be solved. For example, the arch dam test load method program including the arch crown girder method, there must be 20 to 30 of them throughout the country, but their styles vary and their applicability in situations differ. Their basic computation principles or specific formulas differ from each other, and their results of computation are somewhat different, sometimes very different, which brings a lot of difficulties to designers. There are numerous other similar examples.

3. Poor practicality of application programs

Present application programs are solution work programs intended to deal with individual problems and there is a lack of attention to practicality. Their functions of forward and backward processing are poor and sometimes it is necessary to carry out lengthy manual computations to prepare data for input and sometimes it takes a lot of energy to put them into order before one can output a large amount of numerical values and results for selective useful portions. Moreover, the best results of these programs are merely computations of individual problems of individual projects, the results obtained cannot be integrated to aid design so that they cannot achieve the goal of significantly increasing design speed and changing the outlook of design. To draw a common analogy, our programs are merely some automated components and have not been organized into an automated system, not to mention that the quality of certain components have not passed the test.

Many design organs or companies abroad do possess some program systems that can form strong productive forces. For example, in designing the underwater portions of generator rooms of hydropower stations, all it requires is inputting a small amount of data and information, and the machine will make the layout on the basis of past experience and data stored, select the better

scheme and display the types. After it is approved or revised by the design staff, it goes to automatic stress analysis, reinforcement computations and drawing of blueprints and corresponding output documents. Whereas in China, the underwater portion of each hydropower station must be laid out, analyzed, reinforced and drawn from the beginning. The computers can only be used for stress and reinforcement computations. The differences are therefore obvious. When we develop software in the future, not only must we develop more "components" but we must also form "systems" and stress practicality. We must form productive forces and produce economic results, otherwise even if there are more programs we may still be unable to alter the overall outlook.

4. Use of computers in routine management is just beginning

At present, the use of computers in routine management is merely beginning, but those that use computers remain small in number and basically they are still setups of handicraft production and management. The waste of materials, funds, manpower and time is considerable and if we do not strive to change this backward outlook it will be very hard to advance in big strides.

III. Some Proposals for the Present Work

As mentioned above, although some results have been made in the popularization and use of computers in China's water conservancy and hydropower construction, there were still considerable weaknesses, the level of computer application remains low and the disparity is great compared to the advanced levels abroad. In order to change the backward outlook in this area, we must have full-scale planning, conscientiously adopt effective measures and try hard to catch up. For this reason, the following proposals are put forward for the present work:

1. Speedily set up specific programs and software packages for all specialized engineering design.

In present planning and design work, we must speedily build a set of practical and complete application programs (including development by ourselves and importing from abroad for utilization) with planning and in an organized way. Developing such software packages will not only be an emphasis in our future work but it has also been listed as a key project in computer application by the state and the ministry (that is, "computer-aided water conservancy and hydropower planning, exploration survey and design systems and engineering"). After it is studied and arranged, this project will be formed by 5 subsystems, 31 program packages and over 100 specific programs including the various stages and areas of exploration survey, planning, hydraulics and electromechanical design. At present, the strength of water conservancy and hydropower system is being organized and implemented according to plan.

So-called specific programs of various specialized engineering design refer to programs developed according to methods specified by design norms, or according to basically undisputed computation principles and methods if they are not specified by norms but have been generally adopted in regular design.

Programs must undergo trial engineering computation which requires that their mathematical and mechanical models are correct, their program structures rational and compact, their use convenient and flexible, their forward and backward processing function powerful, that they are easy to understand and popularize, and that they must be examined and appraised. Specific programs will become an effective aid to design norms and they will have a certain restraining property. The steps we take to develop specific programs in engineering design are: (1) writing an outline of the specific program for the specialized design; (2) distributing the outline throughout the system for comments, which will be revised and determined; (3) organizing units concerned to divide the work, combine efforts and undertake the tasks; (4) checking and using the program on a trial basis; (5) carrying out an examination and appraisal; (6) popularizing the use of the program; (7) summarizing the problems encountered in using the program, revising, examining and approving it in an organized way, forming a new edition of the specific program and then popularizing its use again. Consequently, establishing specific program and software packages for various professional design is both a relatively painstaking and profound type of work as well as a capital construction in technology, which also represents China's proficiency. All units and software staff undertaking the tasks shoulder arduous and glorious responsibilities which they will carry out conscientiously and complete successfully.

2. Actively strengthen software development

The quantity and quality of computer application programs are the key to computer applications. The development of application programs is complex mental labor while the development type of application programs are both an achievement in production and an achievement in scientific research. A fine application program particularly the establishment of software packages that can form productive forces often requires several years of development and has a repetitive process of practice and revision. Once it is popularized and used, it will create strong productive capability and economic results. We should give preferential consideration of awards, rank promotion and cadre promotion to those outstanding members of the software staff who have contributed to software application in order to overcome the current downgrading attitude toward software. Outstanding members of the software staff will constantly increase in number and they will feel at ease and engage in this work for a long time. If we can achieve this, a brand new situation will emerge in our software undertaking and it will not be difficult for China to rank among the advanced countries in the world.

3. Reward outstanding achievements, mobilize the enthusiasm of different quarters

We should encourage and reward outstanding achievements in computer applications in a planned and organized way, award those outstanding staff members engaged in computer applications in order to give impetus to the development of computer applications. Recently, the ministry's Institute of Water Conservancy and Hydropower Planning and Design has formulated the "Regulations for Appraising Outstanding Programs for Computer Application in Water

Conservancy and Hydropower Construction (trial)." We hope it can give impetus to more rapid development of computer applications. Moreover, generator room maintenance and on-duty staff as well as program debugging operators also contribute in their different posts, and in order to give play to the enthusiasm of different quarters we should make provisions by drawing up regulations of labor insurance treatment and a system of awards.

4. We must arrange for unified machine models beneficial to popularization and use

During the disposition of computers, we must consider whether they are beneficial to popularization and use in the water conservancy and hydropower system. We should strive for unified or compatible models so that we can all share the same resources and use the same programs. In selecting computer models, we must consider the varying circumstances of the tasks of the unit in concern, manpower and financial strength, and select different classes of machines. For the routine management of construction enterprises at present, it is suitable to primarily select microcomputers which are low in price, powerful in functions, flexible in use and are capable of processing Chinese characters.

5. Computation stations (and offices) of all units must gradually develop in the orientation of enterprises

In order to overcome the drawback of eating out of the big pot, implement the principle of distribution according to work and getting more for more work done, and fully mobilize the enthusiasm of staff engaged in computer application, the computation stations (and offices) of all units must gradually develop in the orientation of enterprises and gradually implement the system of contract responsibility. At present, we can first experiment this in a small number of units and gradually popularize it after we get some experience.

IV. Conclusions

Along with the rapid development of China's four modernizations, water conservancy and hydropower construction is increasingly important in responsibility and large in scale. In order to satisfy the needs of the situation, under the current impetus of the tide of the new global technological revolution, it will no doubt set off a high tide of vigorous popularization of computer applications in China's water conservancy and hydropower construction. In terms of the development of computer applications, the following trends deserve our close attention and active promotion:

1. Microcomputers and pocket computers will be rapidly popularized and will drastically change the face of production. Microcomputers and pocket computers are characterized by their low cost, portability, easy maintenance and convenience for use, and they can satisfactorily solve the small computation problems that are frequent in engineering design. At present there are already at least 1,000 of such computers in the water conservancy and hydropower system. In the future, the application of computers are no longer restricted to a minority of special personnel but will be spread to each technician and each member of the management staff. It can be said that in

the future it will be very hard for those who do not understand or do not know how to use computers to be qualified for work in planning and design.

2. The use of computers in routine management will rapidly develop. Along with the perfection of microcomputers with Chinese character function and the performance of Chinese character terminal computers, the increase in the people's knowledge of computer applications as well as the actual needs in routine management, the use of computers in the routine management of water conservancy and hydropower construction will no doubt rapidly develop. It will be very hard for management and other units to advance in big strides if they do not widely adopt computer applications.

3. Computer-Aided Design will be vigorously popularized and used Computer-Aided Design (CAD) is an important realm of computer application developed in the last 10 years or so. Its characteristic is to further strengthen man-machine relationship and dialog so that scheme selection, analysis and computation, design optimization and the output of final results (drawings and documents) will be entirely completed jointly by man and machine, which therefore makes the computer not merely a computation tool but a participant in design. The CAD system can store large quantities of design drawings and various kinds of graphic components (graphic elements) and can revise, edit, piece and assemble, and tailor graphics thereby increasing the efficiency of design work many times and the quality of design will further advance toward the best goal. The CAD system is undoubtedly a revolution in traditional design work. We should fully understand this new technique and import, assimilate and study it without missing the opportunity. It is believed that soon it will be vigorously popularized and used.

We believe that under the care of the leadership at all levels, through the common effort of the broad masses of staff workers in computer applications, and by summarizing past experience and lessons, formulating feasible plans, adopting vigorous measures, strengthening personnel training, mobilizing the enthusiasm of all quarters and formulating technological policies beneficial to the promotion of computer application, the application of electronic computers in water conservancy and hydropower construction will definitely enter a new period, reach a new level, initiate a new situation, and play a greater role in giving impetus to the water conservancy and hydropower undertaking.

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CSO: 4013/20

HYDROPOWER

BRIEFS

XINJIANG'S BIGGEST STATION BEGUN--Urumqi, 23 Jun, XINHUA--Construction work on the Dashankou hydroelectric power station (installed capacity: 80,000 kilowatts) in Xinjiang has recently begun. This is currently the largest single hydropower station in Xinjiang. It is being built in a canyon on the middle course of the Kaidu He in the Bayingolin Mongol Autonomous Zhou. The Kaidu He originates in the Tian Shan range and, after flowing for 156 kilometers, empties into the Bosten (Bagrax) Hu. Plans call for the construction of 11 cascade power stations on this river with a total installed capacity of 1.4 million kilowatts. The Dashankou Hydropower station is the first of these cascade stations and will be completed in 1989. [Text] [Beijing RENMIN RIBAO in Chinese 24 Jun 85 p 1]

CSO: 4013/157

THERMAL POWER

WORK ON BIG NINGXIA PROJECT TO BEGIN IN 1986

Yinchuan NINGXIA RIBAO in Chinese 30 May 85 p 1

[Text] With the consent of the State Council, on 27 April the State Planning Commission formally approved the construction of the Qingtongxia Daba [Big Dam] [thermal] power plant in Ningxia. This project was included in the construction agenda of the Seventh Five-Year Plan. The schedule calls for groundbreaking next year and the first generating unit should be generating power by 1990 (with a possible start-up date in 1989). After the power plant has been completed, it will have a major impact on the economy of Ningxia and on the opening up of the northwest.

The first stage of the construction of the Qingtongxia Daba thermal power plant entails the installation of two 300,000 kW generators using Chinese-made equipment. In order to get the station in operation at the earliest possible date, the first generator will be a joint investment on the part of Ningxia and the Ministry of Water Resources and Electric Power.

The Qingtongxia Daba thermal power plant is located in the middle of our region, in an area with favorable geographical conditions. The most outstanding features are its proximity to the Huang He, the available water, and the fact that no agricultural land will be used; no relocation will be necessary, the terrain is smooth and open and the geological structure good, perfectly suited to the construction of a power plant. Excellent communications are provided by the nearby Baotou-Lanzhou Railroad and Highway. The Helan coal fields are to the north and the Lingwu coal fields (construction pending) are to the east, assuring a supply of fuel. Being close to the peak power load area of the region, it will enhance the regulating capacity of the Northwest Power Grid.

The party committee and government of the Autonomous Region have attached extreme importance to the construction of the Daba power plant and the involved departments have conducted exhaustive preliminary work. At the beginning of last year, the government of the Autonomous Region convened a "Forum on the Feasibility Study of Constructing a Thermal Power Plant in the Qingtongxia Region" to conduct studies and discussions on fuel supply, railroad transportation, and other issues related to the Daba Power Plant. The Ministry of Water Resources and Electric Power has lent tremendous support to our region in the effort to construct thermal power plants and has instructed the Northwest Electric Power Design Institute to draft, on the basis of the requirements of the State Planning Commission and the Ministry of Water Resources and Electric Power, a feasibility study report. The Autonomous Region and the Ministry of Water Resources and Electric Power will then submit a joint report to the State Planning Commission.

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COAL

CREATING A 'CHINESE-STYLE' COAL INDUSTRY ECONOMIC SYSTEM

Beijing NENG YUAN /JOURNAL OF ENERGY/ in Chinese No 2, 25 Apr 85 pp 1-6

/Article by Gao Yangwen, Ministry of Coal Industry/

/Text/ 1. Retrospective Analysis of the Reforms in the Coal Industry Economic System

Why reform the economic system of the coal industry? If it were not reformed, the coal industry would not be able to continue with healthy development and could not continue to open up new frontiers. After the founding of our nation the coal industry went through profound changes, most especially in coal output, the scale of which is unmatched in any other country. Our accomplishments were enormous. But change also created many problems that have been a great burden on us. In the past we called these the "five great pressures": Output pressure; transport pressure; environmental damage pressure; the pressure of too high an accident rate; and the pressure of employing too many personnel. These weights and pressures made every step forward seem like it required 100 percent of our energy.

Naturally the reasons for these problems in production, etc., were numerous. There are historical and economic reasons, particularly the influence from the mistakes of the "left," and particularly in the influence of backward conservative small production ideas and the power of old habits. An investigation of leadership shows that policy errors are another important reason. There was blindness in the area of policy, the objective rules for the development of the coal industry were never well grasped, there was contempt for the intellectuals, for science and technology, for knowledge, for the selective absorption of the ever-changing world coal technology, equipment, and management experience to meet China's needs.

In addition to those things mentioned above, another important reason was that the problems surrounding the pressures on production were never met head on; for a long time the coal industry ossified, and was sapped of its strength.

Where is this ossification reflected? The worst practices were: Planning administration was worse than dead; product distribution was worse than dead; finance was conservative and artificially propped up; the circulation system was worse than dead; labor administration was worse than dead; industrial

capitalization was egalitarian; the pricing system was irrational; the administrative management system was many-headed and cut up. These eight things reflect three problems: 1) the division of duties between government and business was inequitable, cut up, the nation's attitude toward business had become worse and worse; 2) the production of goods was neglected, market forces and the rules of pricing were ignored; 3) the idea of egalitarianism was dominant. To put a sharper focus on it, business lacked the autonomy it requires, business lacked vigor. The coal business was hamstrung by this ossified economic system. We were in a dead end, it was difficult to go forward and impossible to develop and improve.

Where was the way out? It was in reform, to breathe some vigor into the coal business and coal industry. We strove to bring order out of chaos, and we studied and analyzed reforming the coal industry economic system to cut through the red tape of rules and regulations that were binding us, to come out of the dead end and steer in the direction of vigor to ensure that the coal industry could develop, in a good healthy environment.

After the 3d Plenary Session of the 11th Party Congress, reforms came through development of unified distribution mines, locally run and collectively run mines. We proceeded according to the demands of the mission and of conditions, five times we brought together the coal industry's leading cadre and fighters in the trenches to study and discuss reform in the coal industry. We progressively identified the substance of and measures for reform, its kernel element being "responsibility"; and we pushed forward in one part of business. With the reform to the system and the effecting of economic policies, the autonomy of business was expanded, and vigor brought to the coal industry.

In June 1984, another conference on reform was called. Reforms of municipal economic systems had become widespread and well developed, it was an auspicious opportunity for our reforms in coal. With 4 years of study, analysis and experiment in reform, we had accumulated some experience, and we were becoming more and more clear about practice in the coal industry. Our problems seemed to be settled. In 1984 and after we turned our attention to across the board, complete reform. That is to say we took small steps toward reform in those first years; we made fairly large breakthroughs in 1984 and after. After a fairly complete discussion, we formulated the contract program for unified distribution mines and the assignment of coal output quotas as the key issues. There were more than 10 other concrete reform programs for other areas. It could be said this was a small, preliminary step toward completeness. It gave impetus to forward progress in the reform of the coal industry economic system.

Concerning the problem of local and collectively run coal mines, from the very first we completely affirmed that, due to China's special characteristics, great effort must be given to the expansion of local and collectively run coal mines; this area could not be given short shrift, otherwise we could commit a great error. Principle to the development of local and collectively-run coal mines is a liberalization of policies. Economic methods must be used to foster and advance them. We must urge the masses to put their capital into the running

of mines, urge individuals to contract to run mines, urge permission for individuals to invest in mines; pricing must be liberalized, we must go into the market place and follow market fluctuations in pricing; we must urge the broadening of the resource by designating more exploitation of small coal mines; the transport sector must help solve our pbolems; investment must be encouraged to effect the extension of credit; there must be technical assistance by sending out leadership personnel; the availability of safety training squads and mine exploitation chiefs must be greater, technical high school graduates must be sent out to work in the local mines. A certain part of the pooled resources must be used for running local and collective mines and for transportation.

In the reform of the planning system the guiding thought should be less power for the bureaucracy, more power for business. When we consider that coal is one of the goods designated as key to the peoples' livelihood, then that part that comes under the unified distribution system must have follow a plan that has compulsory effect. But these compulsory plans are not the only plans. Within the overall contract program there are plans which reflect a leadership quality, and there are plans which regulate the market. Not only must the small production of village mines be regulated as it enters the market; the production of unified distribution mines that is over quota must also be regulated as it enters the market.

On the price of coal. These last few years we labored under conditions where the pricing of coal has been extremely irrational, and there was no way to effect any regulation of pricing at any one time. Now, in accord with the demands of the law of value, we have concentrated on using economic leverage and proposed, and to some degree effected a multilevel pricing policy. This includes the pricing policy for overquota coal adopted by mines in the East, the economic coal pricing policy adopted in Shanxi, and the multilevel pricing policy included this time in the unified production contract program, including a national unified price, an increased production price, and freedom in pricing overquota coal. The pricing of coal from collective coal mines is opened up, and local mines' pricing is to be determined by the local mines themselves.

In order to smash the "big rice pot" of egalitarianism several provincial bureaus and mining bureaus have worked with a profit responsibility system and hve progressively increased the scope of fluctuating responsibility for tonnage coal wages and they have used worker-effected piece rate wage scales. At the most basic level, for the establishment of small and middle scale mines, they have used the "three responsibility three guarantee" method of responsibility for construction. Large scale mines have also begun to use the system of responsibility for the economics of construction, and they have begun to use the contract bid system.

At this time it would be well to also solve some "mother-in-law" problems that had been a headache for the coal industry for some time. Coal is an important good in the state plan for the peoples' livelihood. The position and action of the coal industry in the peoples' economy has made it necessary at the present to have centralized administration for this mainstay industry going through many changes in regulation. But centralizing administration is not the same as administering to death. We must decrease the government's authority and divide up the responsibility between government and business, to strengthen business activity.

The reform in these years have borne definite fruits. The entire coal industry is developing steadily, healthily, and upwardly. Coal production for 1983 broke the 700-million-ton level, beating by 2 years the goal for the Sixth Five-Year Plan. Again, 1984 saw coal production reach so many hundreds of millions of tons, increasing by tens of thousands of tons over the previous half year. Economic benefits are on the rise, losses are being reduced, the total personnel efficiency ratio is now 0.9/ton. The scale of basic construction has been enlarged, tunnelling for the first 9 months of 1984 was increased 37.7 percent over the same period for the previous year. Overall, conditions continue to improve, the accidental death rate is on a downward trend. The scope of foreign relations has opened up as well, and we have been able to bring in foreign investment through joint operating ventures, compensatory trade, barter trade, cooperative construction and planning, the use of government loans and World Bank loans. The importation of foreign technology and equipment has been increased, with rather good results. In all the coal industry has begun to show an across-the-board liveliness not seen in many years, and has picked up some important lessons in the practice of reform.

As we leaders of the Ministry of Coal Industry view it, the work to date is not enough. Thinking has not been liberated enough, the limits of our steps toward reform are still rather small. Internally we have not really brought the industry to life, and externally we have not been courageous enough in lifting restrictions. Now we are working on the overall contract program, which must be regarded as an incomplete, preliminary, unfinished package. No matter whether in the understanding of reform theory, or of thought, or of the breadth and depth of reform, we are still a long way from the "Resolution."

II. Make the General Contract (Planned Responsibility System) Program and Its Total Package of Reforms the Starting Place For Carrying Out the "Resolution" of the 3d Plenary Session of the 12th Party Congress.

The most pressing task facing us in increasing the reformation of the economic system of the coal industry is putting into effect the total package of reform with the general contract (planned responsibility system) as its center. We are only at the starting line, and in setting in motion the reform of the economic system of the entire coal industry, we must ceaselessly strive to develop in depth, and by means of reform make a good healthy environment for the coal industry to develop in.

During the latter half of 1984, and after, in the work of putting the contract and other regorm systems into place, we ceaselessly advanced, and some are now in operation, such as limiting the administrative power of cadre who have been "sent down," linking wages to tons of coal produced, reforming the use of manpower, relocating the underground workers' families near the mines, etc. Some we are working on right now. These include simplifying government influence and power in five provinces mainstay coal businesses in the area of effecting production, basic construction and fiscal responsiblity targets; building gangue coal and stone coal burning power plants producing 1 million kilowatts, etc. To sum up, there is a lot of work remaining to be done. We must expend a great effort, and work our way from one program to another until at last all are operating.

To put the contract program into effect, we must stress these points:

A. We should work across the board to implement the principle of putting the nation's interests first by putting the contract program into effect. In putting the contract program into effect, we must approach it with across-the-board, overall thinking. What is across-the-board, and overall, for the coal industry? "One doubling guarantees quadrupling" is what across-the-board, overall means, it is the total interest of the country. As far as the unified distribution mines are concerned, the concrete mission of the contract system has been fixed as an across-the-board, overall one; as far as local mines are concerned, across-the-board and overall has been defined as providing 10 million tons per year for distribution to the nation. These tow "overalls' affect the development of the entire peoples' economy. We have been considering the contract system for many years. After giving it thorough consideration, we now hope that it will give the business more freedom, untie business' hands, liven up business, to bring full play to this enthusiastic spirit, to effect "one doubling guarantees quadrupling," to hit 1.2 billion tons. These thoughts are the starting point for the meaning of "overall."

In putting the program into effect, many business have already been thinking in across-the-board terms. But there really are quite a few businesses not thinking in these terms, and have come to a standstill in putting the contract mission into effect. That was to be expected, and this phenomena has arisen in the past when putting new plans into effect. At this critical juncture, one contract for 6 years, with many conditions that cannot be carried out, the hope is to set one's own output responsibility target a bit lower, and to allow oneself higher limits on losses, or to lower ones' own target for net profit, and raise ones' own target for basic construction investment per ton of coal. We number one understanding, but number two do not thoroughly approve of these thoughts and methods of our comrades in business. When I say "understand," I am speaking from the point of view of contracts, which in fact are still rather tight, and the profits are not great. This is what we call a "poverty contract" or a "tight contract." When contracts are tight, and there is not much profit, comrades in business must strive to haggle for terms, this we understand. All the more so when the contract period is for 6 years, and the terms affect the next 6 years' economic profits; who wouldn't be calculating? There will be negotiations, wrangling, setbacks, all this is completely normal. They why do we not completely approve? The problem arises when a certain few businesses see things only in the light of their own business when haggling, so there is quite a distance between the contract terms proposed by the ministry and those proposed by these businesses. There are many mine bureaus that in the past made a profit and think they will continue to make a profit, but what is on the tray they hold out to us is a money-loser. Certain units take rather slack care of business administration, their economic targets are really lagging behind, there is an obvious potential they are not exploiting, but are content to rest on their lagging targets. We feel that if a number of businesses proceed from the point of view of their own small group, their own chicken coop, all thinking of maximizing their own profit, and everyone demurs to their demands, then the responsibilities of the contract system will not be handed down, and if that happens, no one will be able to get the relevant policies and advantages that were to be given to businesses. This is not advantageous

to the nation, and it is not advantageous to coal mines. The effect would be that the small group could not attain its interest, and it would be impossible to influence the across-the-board interest.

For this reason, we especially emphasize the implanting of an across-the-board point of view, the implanting of a point of view that mutually combines responsibility, power, and interest; a unified view combining the state, group and individual interest. Responsibility is the first thing we should stress, the interests of the nation are in first place. In the contract system the nation has already considered the interests of individuals and groups, and has given business much autonomy and advantages. Businesses should think about how to be the most responsible, how to make contributions to the nation. Otherwise, they will not be able to ask for autonomy, profits. If they relax in their duties, the interest of the nation will be harmed.

In the course of the work of the last few months, and especially during the National Coal Industry Conference, we gathered together to discuss several problems; output quotas for contracts and profit and loss targets have been placed in operation, this shows that the leading cadre of the coal industry at every level has an across-the-board viewpoint, and is aware of reform. They have directed their attention to freeing up thought and invigorating business, to reforming structures and policy, to bringing out the hidden potential in business, to make a big profit from a small investment. After seeing the contracts the positive, creative spirit of the great coal workers knew no bounds. Autonomy was increased, policies were liberalized, and the potential for business was very great. It remains for us to do our jobs, carry out our responsibilities, and we can bring out the potential, profits will get bigger and bigger. The practical experience of the Xuzhou mine bureau will all types of mine business is illustrative. Before the contracts, this bureau saw its production going down and losses going up. At the time the contracts came, production was going down by two percent a year, they losing 1 yuan per ton of coal dug. The 1st year after the contracts, production was up by four percent, and they had gone from losing money to making money. In 1984 their production increased about five percent with a large-scale increase in profits. It has not been Xuzhou alone; in the last few years many mine bureaus have dealt with profit and loss responsibility, with good results. The number of units with responsiblity for profit and loss increased in 1984, and economic results were even better. This was accomplished under conditions of very minor reforms. We may predict that with a system change in the economic structure, the potential for business will be brought out even more.

B. We Must Establish the Economic Responsibility System at Every Level.

Establishing a strict economic responsibility system will guarantee the success of the contract mission. Mine bureaus are the basic unit in the coal trade, the substantive level of economics, and if we are to release authority, we must release it to the mine bureaus and equivalent businesses. Contracts must be made directly with the mine bureas. Provincial bureaus (companies) must aid the ministry in putting plans in effect at the mine bureaus, and the mine bureaus must in turn put them in effect at the mines, area teams, groups, and every small post. They must work until the mission is definitely understood, responsibilities are clearcut, and every person knows what he must do. This will bring out the positive qualities in our great workforce.

Responsibility, authority and profit must be joined together in putting the economic responsibility system into effect. Authority that must, under the contract, be given over must be given over. Part has already been handed over; we must continue to do so. After the business has been contracted, then units may use the autonomy given them. Mine bureaus are businesses, and there are problems concerning the distribution of power and profit internally within a business. The workshop for the coal business is not identical to that of other endeavors, there are relatively independent production, supply, consumption and economic calculation systems that must be followed, especially in mines that produce a million or more tons per year. It will be hard for the mine bureau to survive if the mines themselves are moribund. Therefore, the mine bureaus must consider which powers and profits to confer on the mines, how to mobilize the positive spirit of the mines.

In establishing an economic responsibility system it is necessary to link the worker's wages to individual responsibility taken and individual labor results produced, to work toward a situation of "the more you work the more you get." The worker is to be made to understand that if he himself strives to work to a certain level, he will receive a certain profit, so he will give his best. A certain proclivity must be guarded against, and that is the tendency to want to get more money without thought to whether responsibility has been fulfilled, what the production results are, or what the economic results are. If this happens the "big rice pot" still will not have been smashed, and this will negatively affect the interests of the business and those of the state.

The economic responsibility system is key to the whole question of contracts, and is a very complicated undertaking. It affects every unit, every worker, every post, and does so under conditions that are always different from case to case, requiring a conscientious effort to work in a way that is finely calculated and carefully done.

C. Untie Their Hands, Let Them Use Their Autonomy.

In putting contracts and the reform package that goes with them into effect, businesses must have expanded autonomy, under these conditions, businesses may create new vigor. But whether any vigor will be found depends on the efforts put in by each and every bsuiness. Every business, within the scope of its autonomy, must use its head and free its hands to use its authority and use it well, under the leadership of national policy. Whether or not the power is used wisely depends on whether it contributes to coal production ability; that is the test.

First, we must continue to proceed in the direction of socialist management. If we are to benefit from such things as comprehensive utilization, invigoration and increased production, we cannot cheat on weights and short our tons, we cannot misgrade bad coal as good, we cannot let our consumers get the worst of it. We must be fair in our dealings, be civilized in our management, and not take the crooked route. We must respect the fact that the proletariat masses are supreme, we cannot punish them or embezzle their share.

Second, we must have strategic vision and long-term plans. We must organize production along the unique lines of the coal trade, and we must particularly pay attention to long-term plans. We must stress keeping a balance and not creating dislocations. The dislocations are created or other bills are owing, we must investigate and fix responsibility.

Third, we must earnestly carry out the technical policies set by the state, and ensure safe production. We cannot seek after production and profits at the expense of safety, ignore standards, mine in some crazy manner, only mine the rich and disregard the thin; we must hit the targets for resource recovery as detailed in the policies.

Fourth, we must lay a sturdy foundation, raise the quality of the workers and leaders, raise the quality of the business' technology and administration.

D. Rely On Advances in Science and Technology To Implement the Contracts.

We had old-fashioned ideas in the front trenches of the coal industry, feeling that the use of new technology would not bear economic fruit. The very existence of this idea had a profound effect on production. As new technology appeared throughout the world, it greatly increased the development of production capability, and increased wealth for society. In the last few years, we have begun to use some of the new technology and equipment and it proves this point For example, we cooperated with foreign interests in planning the Jining No 2 mine; with the use of new technology the number of pit shafts needed was reduced from four to two. We were able to eliminate the construction of 26,000 meters of work, save a year and half of time, to mine an extra 1.2 billion tons of coal and to recover the 45 million yuan construction cost ahead of time. Using the mechanical face method also has also raised economic benefits. Using advanced technology and equipment can only result in better management and use, canonly raise economic benefits, and definitely cannot lower economic benefits. Thus, we must get rid of our old ideas, and in our reforms seize upon scientific and technical advances.

Putting technical reforms into place is an important technique for the promotion of the advancement of science and technology, and is an important measure for increasing coal production and achieving the contract mission. The average annual increase in production for the unified distribution mines over the contract period is 20 million tons, and this can't be done by relying solely on new mines; we must modernize and transform our existing mines, and bring out their potential. Transforming does not simply mean the expansion of production, but changing the face of technology, making a substantial savings of labor and increase in labor efficiency, and an improvement in safety conditions. Thus, in transforming we must use advanced technology and equipment, and not recreate the past; we cannot do new engineering work without using new technology.

III. Continue To Liberate Thinking; Cause the Reform of the Economic System of the Coal Industry To Develop Unchecked and Become Perfected

The basic mission in the reform of the coal industry is: In accordance with the spirit of the Central Committee of the Communist Party's Resolution on the Reform of Economic Structures, integrate the realities of the coal industry,

liberate thinking, sum up historical experience, advance into new areas, progressively establish a socialist coal industry economic system which is vital, vigorous and "Chinese."

In accord with the above basic mission, we are conducting an investigation of how to increase the vigor of the coal business, an matter which revolves around this key issue. The central issues are as follows:

A. How To Establish a Coal Industry Planning System Which Correctly Uses the Law of Value?

Coal is our nation's primary resource, an important good for the peoples' livelihood. The important position of coal in the peoples' economy itself determines the fact that the state will continue to exercise rather more control over the coal industry's planning, distribution, transport, pricing, etc. How can we establish a coal planning system which is unified and at the same time flexible? How will we bring the law of value into play? What methods will we use to give the unified distribution mines the autonomy they should have over management and production of goods, and at the same time survive? These are the core questions of survival facing the coal industry, and there are several interconnected questions:

First, given the concrete conditions of the coal industry, how are we to distinguish "order"-type plans from "guideline"-type plans and market regulations? When unified distribution mines have followed order-type plans and distributed all their coal, that is coal distribution both nationwide and locally, what part of the coal may be used to carry out guideline-type plans and market directives? What part of the unified distribution coal mines may be used to follow the guideline-type plans? When it comes to collective management and individual management, how will market directives be carried out? Which administrative system and which policies should we urge on there mines to coordinate development?

Second, how can we reduce "order"-type plans? Can we come up with a order-type planning target which is follows the basic numbers of the contract responsibility system, and progressively shrink the order-type planning targets down to coal which comes from comprehensive coal production capabilities, and include any coal over those targets in the guideline-type plans and market directives?

Third, how can we use economic leverage to effect the order-type plans on those coal mines and ensure the meeting of the order-type targets? How can we use the law of value and economic leverage to effect the guideline-type plans to mobilize the positive qualitites of the business increasing production and practicing economy?

B. How May We Establish a Rational Pricing System and a Rational Price Control System?

The price of coal is too low, and this has been a serious impediment to the growth of the coal industry. A key issue in the reform of the coal system is the creation of a rational pricing system.

Coal production is not like the manufacture of goods, the goal of labor is to reach resources buried underground, and as the resource is constantly being removed, the work place must follow the resource ever deeper, ever farther away. This characteristic results in two special features to coal production: 1) The production capacity we had to start with is always being diminished. The more we dig, the less there is to dig. Naturally our production capacity will become attenuated. Thus we must invest more money and create new production capacity, if only to keep at the level of production capacity we had to start with. 2) Normal coal production costs have a tendency to increase progressively. The more coal we dig from a mine and the deeper the mine becomes, the higher our fixed costs become. When we add to that the fact that expense beyond the cost of doing business are also rising, we see that these conditions in coal production mean that the normal costs will fluctuate according to the conditions of production. For a long time the price of coal was fixed and unchanging, resulting in the cost of coal not reflecting the value of coal, and not reflecting supply and demand. This lack of connection between price and value became worse as time went by. We must proceed from the special conditions of coal production and the status quo of low coal prices to study the establishment of a coal pricing system.

First, how should we adjust prices in accord with the principles of exchange for equal value and with the fluctuations of supply and demand in a way that will ensure the coal business of being completely compensated for its production costs, and will ensure the achievement of rational profit levels, but without having an untoward influence on the cost of other goods? Should we use small-scale part measures step-by-step; or should we use the appropriate large-scale price adjustments and quicken our pace toward price adjustment? Should we expand the suggested price portion and shrink the unified fixed price portion? Or should we expand the unified fixed price portion and increase the range of fixed prices?

Second, how do we integrate unified fixed prices, floating prices and free pricing? How do we create multilevel pricing for that part of the coal under "order"-type planning targets?

Third, how do we establish a graded price administration system for state, locality and business?

To summarize, we must study how to put coal on a basis of state unified fixed pricing. Then we will be able to respond to improvements in labor and production efficiency, and to market supply and demand; we will be able to utilize the law of value, and invigorate the coal economy.

C. How May We Create a Beneficial Investment System For Basic Coal Construction?

The resource in coal mines is limited, and there is a natural tendency for production capacity to be worn right down to nothing. The excavating nature of the industry dictates the fact that the industry must always be concentrating on expansion to create new production, and always be transforming through renewed and expanded construction, and increasing production capacity. But basic construction takes a long time, the investment is great, and the pay back

is slow. This causes many difficulties in expansion and renewal for the coal industry. This requires that in the process of reform, we study appropriate investment systems and investment policies, and open up a variety of channels for funding, to ensure that there will be sufficient funding for the development of the coal industry. The overall scope of fixed capital funding, including investment, scope of construction, ability to go into production, all comes under order-type planning, and must be done in under the controls of the plans, in equilibrium throughout the country, to ensure it is effected. But when state funding is not enough, what policy do we make to mobilize every aspect of positive qualities and to collect every type of funding, Including the surplus funds of businesses in domestic coal burning businesses and coal consuming areas, and also foreign funding? How do we proceed on a basis of ideally transforming and expanding the mines we now have, and at the same time maintain the scope of new mine construction, shortening construction time periods, lowering construction costs and improving engineering quality? How do we reform geological exploration and how do we reform mine design?

D. How May We Establish Comprehensive Utilization of Coal, a Management System With a Variety of Management Styles, and Open Up the Path to Joint Management and Cooperative Investment?

Coal is a natural resource, widely distributed, which knows no political administrative boundaries. The varieties of coal differ tremendously, and the place of production may not be convenient to the place of consumption. This all means that the coal industry's production and construction is intimately connected with other major undertakings, such as railways, harbors, electric plants, chemical industry, metallurgy and mechanical industry. This requires that in reforming, we must pay heed to eliminating local boundaries and commercial boundaries, but instead develop comprehensive utilization and a variety of management styles. We must study the possibilities for joint management and cooperative investment by coal-electric, coal-chemical, coal-steel and coal-transport interests in light of system and policies. We must increase the pace at which we process coal, including washing, screening, shaping, and gasification. There are many problems in the area of systems, policies, and thought concerning the questions of comprehensive utilization and a variety of management styles, and while we have put forth our efforts in the last few years, we have in fact made no large breakthroughs.

E. How May We Establish a Variety of Labor Systems and Wage Systems Which Are Responsive to the Characteristics of Coal Production?

Coal mine production is underground work, work conditions are poor, the level of mechanization is low; it is hard, tiring and dangerous. Proceeding from this premise we must study, on the one hand, what technical policies are appropriate and develop mechanization, to raise the levels of safety and equipment; on the other hand, we must investigate how to establish appropriate labor systems and to stabilize the mine workforce and raise its quality. We must study how to intimately link workers' wages to the fruits of their labors, to increase the wage differential between surface workers and underground workers, increase the wage differentials between brainwork and physical work, between general work, complex work and simple work, as well as between skilled work and unskilled work. We must raise intellectual mine workers' wages to

the point that everyone will be envirous, or even "covetous." Then workers will be attracted into the mine pits, and intellectuals from other undertakings will be attracted into coal mining.

There is another question that must be studied at the same time, and that is how are the ministry apparatus and provincial bureaus to reform, and how are they to correctly bring into play the coal administrative functions in state organizations, and to join hands with those in every aspect of the coal system, including geology, sicence, design, cultural work, research publishing, etc., to make a complete reform.

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CSO: 4013/137

COAL

BRIEFS

JILIN OUTPUT UP--The collieries run by both the state and localities throughout Jilin Province have enhanced their vitality thanks to the enforcement of the responsibility systems. As of the end of June, they mined 2 million tons of raw coal and overfulfilled their production plan by 15 percent, a 150,000-ton increase over the figure for the corresponding 1984 period. [Summary] [Changchun Jilin Provincial Service in Mandarin 1030 GMT 9 Jul 85 SK]

NEI MONGGOL DEPOSIT--Shenyang, 30 Jun (XINHUA)--A brown coal deposit estimated at 17 billion tons has been found recently in the Inner Mongolian Autonomous Region, a local geologist said here today. The deposit, in Abagnar Banner, Xilin Gol League, lies under 342 square kilometers of land, and is from 8 to 200 meters deep. It was explored by the northeast China-Inner Mongolia Coal Geology Prospecting Bureau. [Text] [Beijing XINHUA in English 0641 GMT 30 Jun 85 OW]

CSO: 4010/162

OIL AND GAS

IMPORTED DRILLING RIGS, DIESELS, PUMPS TO BOOST SHENGLI OUTPUT

OW090847 Beijing XINHUA in English 0706 GMT 9 Jul 85

[Text] Beijing, 9 Jul (XINUUA)--The Shengli oilfield, China's second biggest, has signed agreements to import 47 items to accelerate the development of its petroleum resources, today's PEOPLE'S DAILY (overseas edition) reported.

The import schemes include four drilling vessels for exploiting the newly found Gudong shallow sea oil block. The first of the four, which can drill 9,000 meters, has already reached Yantai port in Shandong Province. It will go into operation in September.

The oilfield has also introduced large slush pumps and diesel engines from the United States and Japan.

Simultaneously, the oilfield has invited six foreign teams to cooperate in oil production, drilling, oilfield construction and dealing with special problems of oil-bearing strata. At present, four teams from the United States and France are working there; the other two will arrive later this year.

The Shengli oilfield was opened up in 1961. It has made marked progress in oil exploration and production in recent years. The oil reserves discovered in 1984 exceeded the total verified in the previous two decades. The cumulative reserve in this area matches that in China's biggest oilfield --Daqing in northernmost Heilongjiang Province.

China plans to increase the annual crude oil output of Shengli from the present 140 million bbl to 350 million bbl by 1990.

CSO: 4010/162

OIL AND GAS

BOHAI FIELD SLATED FOR TRIAL PRODUCTION BY OCTOBER '85

OW171150 Beijing XINHUA in English 1120 GMT 17 Jun 85

[Text] Beijing, 17 Jun (XINHUA)--An offshore oilfield in the Bohai will start trial production around September or October, said a spokesman from the China National Offshore Oil Corporation (CNOOC) in an interview with XINHUA today.

Ninety-five percent of the early-phase construction of the Chengbei oilfield, covering 9.2 sq km, has been completed with 56 production wells drilled.

Production, living, oil-storage platforms, and a wharf for 15,000-ton ships have been installed in Zone B, the first of the two zones in the oilfield to go into production, said the spokesman.

The field was jointly explored by Chinese and Japanese oil firms.

CSO: 4010/162

OIL AND GAS

TEST WELL PROVES QINGHAI OIL RESERVE

OW262006 Beijing XINHUA in English 1649 GMT 26 Jun 85

[Text] Xining, 26 Jun (XINHUA)--A test oil well at an elevation of over 3,400 meters in the western Qaidam Basin in Qinghai Province is gushing an average of 700 barrels daily.

The "Lion 20" well has produced 70,000 barrels of crude oil and 4 million cubic meters of natural gas since 10 February.

The well, 4,564.5 meters deep, has proved what geologists inferred, that the oil reservoir is buried deep in the area.

The basin has a deposit area of 120,000 square kilometers.

Five gas fields and 15 oil fields have been discovered over the past 20 years. But most are still being prospected.

Another four deep wells are to be drilled in the area.

CSO: 4010/161

SHANGHAI PETROCHEMICAL TRADE FIRM BEGINS BUSINESS

OW282215 Beijing XINHUA in English 1638 GMT 28 Jun 85

[Excerpt] Shanghai, 28 Jun (XINHUA)--The Gaoqiao Petrochemical International Trade Company of China will begin business on 1 July, an official from the company said here today.

The company, approved by the Ministry of Foreign Economic Relations and Trade, will run imports and exports of petrochemical technology and equipment, products, and raw materials and carry out project design and construction.

The company is an entity incorporating production and business.

The Shanghai Gaoqiao Petrochemical Corporation, one of the two sponsors of the company, has an annual production capacity of 4 million tons of oil products and 100,000 tons of chemical products, plastics, synthetic rubber, and fibers.

During the period of the Seventh Five-Year Plan (1986-1990), the corporation is to be expanded to refine 7 million tons of oil a year.

CSO: 4010/162

OIL AND GAS

DISTRIBUTION AND GEOLOGICAL BASES FORMING STRATIGRAPHIC-LITHOLOGIC POOLS IN TERTIARY OIL BASINS IN EAST CHINA

Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese Vol 5 No 2, Apr 84 pp 1-9

[Article by Hu Jianyi [5170 6015 5030], Xu Shubao [1776 2885 1405], Tong Xiaoguang [4547 0879 0342], and Lin Dianzhong [5677 3013 1813] of the Petroleum Exploration and Development Research Academy]

[Text] Abstract

This article first of all discusses the regional geological basis for the formation of stratigraphic-lithologic pools: 1) There are two types of fault basins; 2) continental facies lake basins have three types of sedimentary systems and five types of reservoir rock bodies; and 3) there are three types of stratigraphic overlap unconformities associated with source beds. The important question of the formational conditions and characteristics of stratigraphic-lithologic pools also is discussed. The authors then present a distributional model of stratigraphic-lithologic oil pool accumulation zones. This is of some importance in exploration for stratigraphic-lithologic pools.

Introduction

The Bohai Gulf, Nanxiang, Jianghan, Subei, and other Tertiary basins in eastern China already have been proven to be petroliferous regions with rich resources. A large number of anticlinal structural oil and gas pools have been discovered, as well as some stratigraphic-lithologic oil and gas pools. This has made this region an important oil production base area in China. Exploration in some of the depressions now has entered the "relatively mature" stage, but exploration for stratigraphic-lithologic oil pools is at a fairly low level. There are great prospects for finding oil. The strengthened work in the area of exploration for stratigraphic-lithologic oil pools in recent years has brought about some achievements. Exploration for stratigraphic-lithologic oil pools has become an important sphere of prospecting in this region.

I. The Geological Basis for the Formation of Stratigraphic-Lithologic Oil Pools

There is a certain amount of regularity in the distribution of stratigraphic-lithologic oil pools, and there also is a certain amount of concealment. This region has favorable conditions for the formation of stratigraphic-lithologic oil pools. It has the structural characteristics of a basin that has been subjected primarily to faulting and the characteristics of lake basin sediments, and is controlled mainly by the type of accumulation rock bodies, stratigraphic overlap unconformities and other factors.

1. Classes and characteristics of fault basins

This region has different geodesic structural elements and crystallized bedrock that was formed during different periods. Moving from north to south, it may be divided into the North China Platform, the Qinling Hercynian Folded System and the Yangzi Platform. A long geological history of gradual hardening and joining that continued up to the Indo-Sinian orogeny caused the formation of a relatively unified continental land mass.

Beginning with the Yanshan movement, the entire region entered the developmental stage of Mesozoic and Cenozoic fault activity and underwent three periods of activity that may be grouped into the late Jurassic--early Cretaceous, the Paleocene--Eocene, and the Oligocene. They resulted in two groups of fracture network systems with a NW or NE orientation. Block-fault body structures and Mesozoic-Cenozoic scoop-shaped fault subsidence basins developed with a certain distributional regularity along these fracture systems. The differences in the pre-Mesozoic geological structures and intensity of fault activity during the Mesozoic and Cenozoic may be used to classify the many fault basins in this region as contemporaneous fault basins and later fault basins.

Contemporaneous fault basins: On a background of block fault activity, certain unconnected depressions gradually united to form a single sedimentary basin. Each of the depressions and sedimentation-structural systems themselves became a generation-accumulation-capping combination and component of rich oil and gas accumulations. An example is the Bohai Gulf Basin that is located on the North China Platform. Under control by three periods of Mesozoic-Cenozoic block fault activity, it formed alternating concavo-convex block fault structural systems and an overlapping scoop-shaped depression. The basement fractures control the occurrence of the depression and the distribution of lithofacies zones. There was intense block fault activity and the structure is asymmetrical. There are major changes in lithofacies zones and sedimentary hiatuses, and superimposition of unconformities developed to the extent that there is direct unconformous contact between the lower Tertiary oil generating rock system and older strata. This favored the formation of many types of stratigraphic-lithologic oil pools.

Late depression basins: Under control of block-fault activity during the later period, the sedimentary basins that had become united in the early period were separated and changed into alternating separated depressions.

An example is the Subei Basin, which is located on the Yangzi Platform. It is a Paleocene-Euocene sedimentary basin and the primary oil-generating rock system, the Funing group of sediments, is widely distributed. The Dainan-Sanduo group scoop-shaped depression formed because of intensive block-fault activity during the Oligocene that separated and transformed the original sedimentary basin. This formed generation-accumulation-capping combinations and relationships composed of different sedimentation and structural strata systems. Fault activity during the later period affected the maturity of the oil-generating rock from the earlier period as well as the preservation of oil and gas and the degree of accumulational richness. The Paleocene, Eocene and Oligocene systems all had the capacity to form stratigraphic-lithologic oil and gas pools, but these oil pools had to undergo a process of repeated oil and gas migration and accumulation, redistribution, remigration and re-accumulation.

2. Characteristics of lake basin sediments and categories of oil accumulating rock bodies

The Cenozoic sedimentary basins in eastern China are a series of separate near-sea inland basins. Fluvial and lake sedimentation systems are found in all of them and fluvial [forces] played the primary role. Under control of the paleoclimate, ancient terrain and river basin systems, there are many lake basin sedimentation systems and reservoir rock systems. The lithofacies zones are distributed in a ring-like manner along the depression lake basins. Differences in the geological structures and sedimentary environments of the basins meant that the sedimentation systems and categories of reservoir rock bodies are different for each different type of lake basin. A full grasp of regularities in their formation and distribution can aid in the search for stratigraphic-lithologic traps of different types. Overall, the sediments of the eastern lake basins have the following characteristics:

1) Fluvial water systems controlled the formation and distribution of reservoir rock bodies. There are two primary directions of flow in the lake basin water systems in eastern China: northeast and northwest (or east-west). Most of the lake basin water systems have the characteristics of sustained development, and there were occasional shifts in the direction of the lake basin water systems. Under control by the ancient landforms and paleoclimatic conditions in the lake basins, three categories of fluvial water systems developed at different locations in the lake basins: A-seasonal diluvial flows, B-short mountain slope fluvial flows, and C-plains-type long fluvial flows.

2) The sedimentary environments in the lake basins controlled lake facies sedimentation systems. The sediments can be divided into terrigeneous clastic rock lakes, gaoyan [5221 7770] rock lakes and carbonatite lakes. Warm and moist paleoclimatic conditions and ample precipitation led to fairly developed fluvial systems. There was an ample supply of detrital materials that formed terrigenous clastic rock lake basins. Moving from the margin to the center of the lakes, these mainly developed fluvial-deltaic sedimentation systems with secondary alluvial facies (most fault-subsidence basins do not develop them), deltaic plain facies, deltaic frontal margin facies and prodelta facies. An example is the Sha 2 segment sediments in the Liaoxi depression (Figure 1).

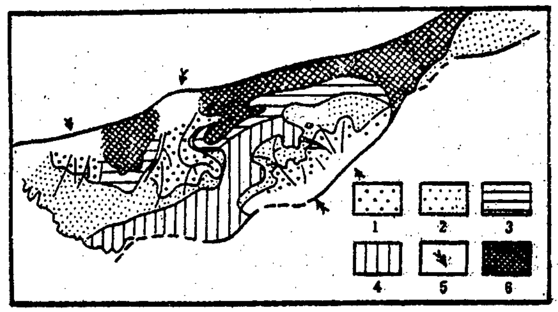

Figure 1. Sha 2 Sedimentation System in the Liaoxi Depression
(based on data supplied by the Liaohe Oil Field)

Key:
1. Tributary flow river channel subfacies
2. Sandbar, mat-type sand subfacies
3. Arenaceous shallow river subfacies
4. Prodelta facies
5. Direction of material source
6. Zone of denudation

Evaporation rates were high under hot, arid paleoclimatic conditions with little rainfall, and the lake water in the occluded or semi-occluded lake basins had a high saline content. The chlorine ion content in the mudstone is generally 2 to 6 percent, forming gaoyan rock lake basins. Under the influence of a single direction of material sources, they formed alluvial cones (or deltas) and gaoyan rock sedimentation systems. The degree of salinity increases as one moves from the margins of the lakes toward the center with secondary deposits of clastic rock, allochemical limestone, dolomite and gaoyan rock in the sedimentary sequence. An example of the Qian 4 segment sediments in the Qianjiang depression (Figure 2).

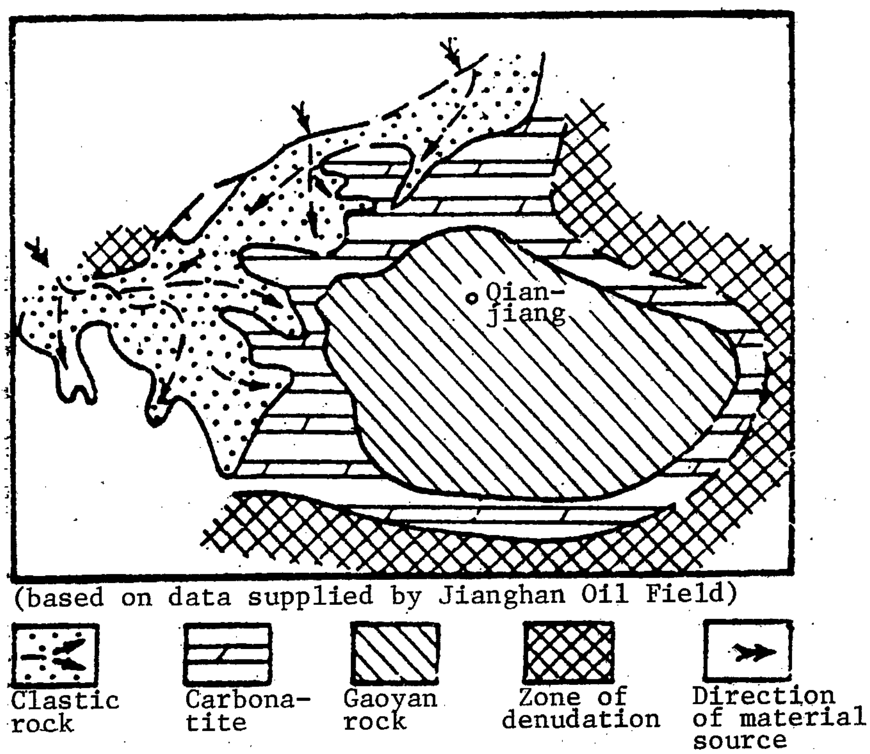

Figure 2. Qian 4 Segment Sedimentation System in the Qianjiang Depression

The ancient terrain on the background of sustained stable subsidence was rather flat. There was an inadequate supply of detrital material in the occluded and semi-occluded shallow lake bays, and they formed lake facies carbonatite lake basins. They have a secondary sedimentary sequence of marl, oolitic limestone, algal limestone and dolomite. An example is the Sha 1 segment sediments in the Dongying depression (Figure 3).

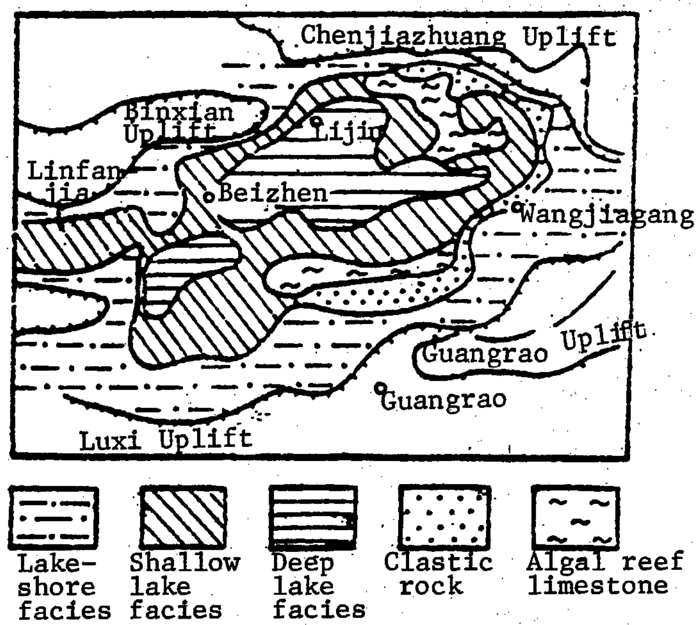

Figure 3. Sha 1 Segment Sedimentation System in the Dongying Depression

3) Categories and distributional characteristics of reservoir rock bodies in lake basins. Identical paleoclimates and a similar background of ancient terrain often led to similar sedimentary environments and distributions of reservoir rock bodies. The lake basins in eastern China can be divided into five categories according to their reservoir rock bodies and lithologic combinations: alluvial cones, deltas, lake-bottom fans, biodetrital and algal limestone, and lenticular sand bodies (Table 1). All of these reservoir rock bodies are wedge-shaped and thin out in the oil-generating rock bodies. Their lithologic thinout zone is coordinated with a particular structural background and forms many types of primary lithologic traps.

There are many types of reservoir rock bodies in depression lake basins. There are major changes and they occur on a fairly small scale. Their planar distribution is controlled by the geological structures of the lake basins and there is mutual overlap or evolution of each type of reservoir rock body moving in a vertical direction. The asymmetry of the depression lake basins also reflects differences in sedimentation. Alluvial cones, lake-bottom fans and small fan deltas are distributed on the steep slopes. Large areas of biodetrital or algal limestone and lake-bottom fans or deltaic sand bodies are distributed in zones with gentle slopes. The ends of the lake basins developed large deltaic sand bodies and there are prodelta facies and lenticular sand bodies in the central part of the lakes. Under the control of multiple periods of block-fault activity, different types of reservoir rock bodies often are found in identical positions in the lake basins. Moving from bottom to top, there are alluvial cones, lake-bottom fans and fan deltas that may overlap each other and which have relationships of mutual transition (Figure 4).

Table 1. Classification of Reservoir Rock Bodies by Characteristics

Characteristics: / Categories	Distributional characteristics	Formational characteristics	Sedimentation characteristics: Lithologic combination	Sedimentation characteristics: Mineral characteristics	Sedimentation characteristics: Stratigraphic characteristics	Typical example
Alluvial cones	Along the steep banks of lake basins in a beaded arrangement, forming cones.	During the early period of lake basin development, there were large elevational differences in the ancient terrain. They were subject to the forces of seasonal flooding. They are mud and rock flow accumulations.	Mainly sandy shale interbedded with thin layers of mixed color mudstone.	Conglomerate of different constituents, uneven size, extremely poor sorting and rounding, major changes in material quality.	No stratigraphic structures, with local graded stratigraphy.	Conglomerate alluvial cones in the Sha 4 member on the northern slope of the Dongyin depression.
Deltas	Located at the conjunction of fluvial and lake water, forming fan shapes.	During the stage of lake basin inversion and uplift, the warm and moist paleoclimate, fluvial water systems were fairly developed and there was an abundance of detrital material. The deltas were formed through joint river and lake forces.	Formed of pro-delta mud, delta front margin facies and deltaic plains in three zones and three strata. The sand bodies migrated into the center of the basins and grew.	Highly mature sandstone that is well sorted, of pure constituents, even particle size and good material quality.	Mainly wavy interbedded strata, mainly skipping bodies.	Deltas of the Sha 2 member in the Liaoxi depression.
Lake-bottom fans	The steep slopes are flood-water type lake-bottom fans. The gentle slopes are turbidity current lake-bottom fans.	During the period of full basin development and the transgression stage, they were formed by the forces of the underwater flows in the river channels and on the lake bottom after the current entered the lakes. Very dense deposits formed in the deeper lakes.	Mainly sandy conglomerate with a normal cycle, coarse at the bottom and fine at the top. They are formed of three horizontal components, the fan base, middle of fan and fan tip.	The steep slopes are of a floodwater type, low maturity, poor sorting and mixed constituents. The steep slopes are of a turbidity type, higher maturity, good sorting and good material quality.	Baoma sequence and graded stratigraphy rather developed, mostly suspended bodies.	Lake-bottom fans at Shuanghe in the Biyang depression. Lake-bottom fans at Liangjialou in the Dongying depression.
Bioclastic or algal limestone	Around ancient underwater uplifts in the ancient bays of the lake basins.	During the stage of sustained basin development, the ancient terrain was flat and the water bodies were shallow and clean. They are biochemical deposits.	Formed of ostracoda, gastropoda, algae, foraminifera and other organisms in conjunction with dolomite.		Block-type inclined stratigraphy or no stratigraphy.	Sha 1 member bioclastic limestone in the Qikou depression.
Lenticular sand bodies	Scattered sand bodies are found in fairly deep and deep regions in the middle of the basins.	They were affected by the surrounding fluvial water systems. Scattered sandstone bodies are found in fairly deep water areas of the lakes at the front end of deltas or lake-bottom fans.	Mainly normal-cycle conglomerate, coarser at the bottom and finer at the top.			Sha 3 member sands to lens bodies in the Dongying depression.

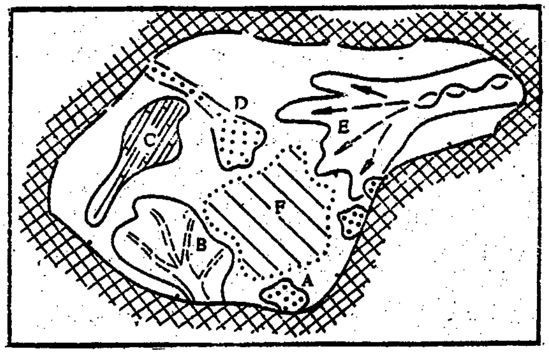

Figure 4. Distribution of Reservoir Bodies in Depression Basins

Key:

A. Alluvial cone
B. Sloping lake-bottom fan
C. Clastic rock
D. Gentle sloping lake-bottom fan
E. Delta
F. Lenticular sandstone distribution region

3. Stratigraphic overlap unconformities

Under control by multiple periods of block-fault activity, repeated instances of transgression and regression occurred in the lake basins, and there are multiperiod stratigraphic overlap unconformities and sedimentary hiatuses in the stratigraphic sequence. For this reason, stratigraphic overlap unconformities are the joint product of the role of structures, erosion and sedimentation. Analysis indicates that stratigraphic overlap unconformities related to the oil-generating rock systems were important factors in stratigraphic trap oil pools only during the primary developmental stages of transgression in the basins. Based on the interrelationship between oil-generating rock systems and stratigraphic overlap unconformities, the following categories of stratigraphic overlap unconformities were conducive to the formation of stratigraphic oil pools (Figure 5):

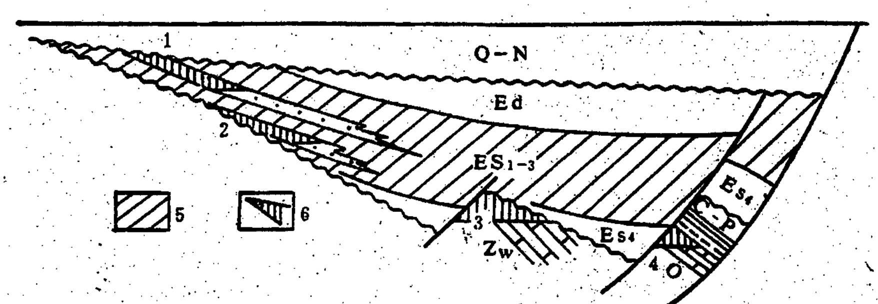

Figure 5. Stratigraphic Overlap Unconformities in Oil and Gas-Bearing Basins

Key:

1. Unconformity trap
2. Stratigraphic overlap trap
3. Ancient buried hill trap
4. Ancient buried hill concealed trap
5. Oil-generating rock system
6. Trap

1) Stratigraphic overlap unconformities at the bottom of oil-generating rock systems. Under control by sedimentary block-fault activity, the lake facies sediments continued to expand and led to oil-generating rock system stratigraphic overlap unconformities on top of the uplifted ancient terrain in different strata positions of the ancient strata. The oil-generating rock systems not only are oil source beds but are excellent regional capping strata as well, making up an oil combination of "oil generated in new strata and reservoired in old strata" that formed new entrapment conditions. Examples include the "ancient buried hill" oil pools in the Bohai Gulf Basin.

2) Stratigraphic overlap unconformities at the top of oil-generating rock systems. During stages of repeated uplift, the fluvial and swamp facies sediments at the margin of the lake basins overlapped directly as an unconformity on top of the lake facies oil-generating rock systems. Regional mudstone capping strata situations appeared in areas with swamp facies mudstone. Most of the stratigraphic overlap unconformities, however, formed excellent trap conditions only when they were capped by permeable strata which may have formed heavy oil and bitumen trap conditions under special conditions. An example is the unconformity trap between the upper and lower Tertiary strata on the gentle slopes of the depressions.

3) Stratigraphic overlap within the lake basins. The lake basins gradually expanded in scale during the process of transgression, causing the lake facies sediments from bottom to top to overlap the downward-sloping older strata. They overlap not only the zones with gentle slopes, but also overlap in the direction of steep slopes. When the downward-sloping strata were composed of impermeable strata, they became an excellent baseboard for stratigraphic overlap traps. During the period of Oligocene sedimentation, each of the depressions in the Bohai Gulf Basin underwent about three instances of transgression, and there are three corresponding stratigraphic overlaps. The scale of stratigraphic overlap is greatest for the middle and lower parts of the Sha 3 member and the lower part of the Sha 1 member. Moreover, it caused the scope of mudstone distributions to be larger than the distributional scope of the sand bodies in their lower part. Stratigraphic overlap zones on the slopes of depressions or at the margins of ancient uplifts that formed dense traps are conducive to the formation of overlap traps.

Moreover, the unconformities within the strata formed prior to basin formation (oil-generating rock systems) are one of the elements in stratigraphic oil pool traps. They must be matched with faults and other factors before an excellent generation and accumulation combination can be formed. Examples include the block-fault traps within "ancient buried hills." In some situations, the lack of an excellent generation and accumulation combination is not conducive to the formation of stratigraphic oil pools even if the trap conditions exist.

II. Categories of Stratigraphic-Lithologic Oil Pools and the Conditions of Their Formation

An analysis of the regional geological background described above indicates that the necessary conditions for formation of stratigraphic-lithologic oil pools are as follows:

1) The various classes of reservoir rock systems at the margin of the depressions all have a wedge shape and thin out in the lake facies argillaceous rock bodies. Lithologic thinout zones or lithologic dense zones that are excellent traps can form at their front edge.

2) Transgression in the lake basins was conducive to the overlap of impermeable argillaceous rock over successive strata moving toward the margins of the lake basins that cover the downward-sloping reservoir rock bodies, causing tight entrapment conditions at the lines of stratigraphic overlap.

3) Above and below unconformities, the top and bottom plates of the reservoir rock bodies and shaded areas to the sides of the faults must be composed of mudstone, sapropel, dense hard carbonatite, volcanic rock, metamorphic rock and other impermeable rock strata for excellent sheltering conditions to exist.

4) With the exception of lenticular sandstone traps, the stratigraphic-lithologic traps in most situations are dependent upon large-scale uplifted slopes, and all of them have a certain regional or local structural background.

To summarize the above, the formational conditions of stratigraphic-lithologic traps can be divided into three lines and three planes. The three lines are the lines of lithologic thinout, the lines of stratigraphic overlap and structural contour lines. The three planes are the stratigraphic unconformity lines, the planes of the upper and lower plates of the reservoir rock bodies and fault planes. There is an organic coordination of these six basic components and they can form many different categories of stratigraphic-lithologic traps.

Based on the trap components and the six basic elements described above, stratigraphic-lithologic oil pools can be divided into three main groups and nine subgroups. The three main groups are lithologic oil pools, stratigraphic oil pools and compound stratigraphic-lithologic oil pools. The nine subgroups are: sandstone upward include thinout oil pools, fault-shielded lithologic oil pools, lenticular lithologic oil pools, allochemical limestone lithologic oil pools, fissure interlayer suture lithologic oil pools, "bedrock" block stratigraphic overlap unconformity oil pools (i.e., "ancient buried hill" oil pools), stratigraphic overlap oil pools, stratigraphic unconformity oil pools and mixed stratigraphic-lithologic oil pools (Table 2).

1) Sandstone upward incline thinout oil pools. The frontal edges and flanks of lake basin deltas and lake bottom fan sandstone bodies are distributed in coordination with depression slope zones, large-scale uplifts or local structures. This causes the thinout lines of the sandstone and the structural contour lines to intersect, forming sandstone upward incline thinout traps. This type of trap pierces directly into the oil-generating rock bodies. There are good generation-accumulation-capping combinations and sufficient oil sources. The physical properties of the accumulated oil are good and the oil quality is light. The degree of rich oil and gas accumulation is high. They belong to the class of primary lithologic oil pools. Their scale and distribution

Table 2. A Classification of Stratigraphic-Lithologic Oil Pools

Category: Major category	Subcategory	Trap factors	Typical examples
Lithologic oil pools	Sandstone upper incline thinout oil pools	1. The facies of the sandstone bodies change to mudstone moving in an upward direction. 2. Lithologic thinout lines intersect structural contour lines. 3. Block-type or strata-type oil pools.	Shuanghe oil field Gaosheng oil field Zhaoao oil field
	Fault sheltered lithologic oil pools	1. Lithologic thinout lines match fault planes. 2. Good fault incline sheltering conditions. 3. Block-type or strata-type oil pools.	Liangjialou oil field Dalinghe oil pool in the Huanxiling oil field
	Lenticular lithologic oil pools	1. The sand bodies are surrounded on four sides by impermeable mudstone. 2. Formed independent oil and water systems themselves, with low water.	Ying 2 well oil pool in the Dongying depression
	Clastic limestone lithologic oil pools	1. Lithologic density zones intersect structural contour lines. 2. Block-type or strata-type oil pools.	Zhouqingzhuang region in the Qikou depression
	Fracture interstrata lithologic oil pools	1. Limestome fractures and areas of interstrata suture development are limited by density zones. 2. Oil and gas are unevenly distributed.	Sha 4 member oil pool at Fengheying
Stratigraphic oil pools	Bedrock block overlap unconformity oil pools	1. Unconformities are combined with faults or baseplate impermeable strata. 2. Residual mounds formed by the ancient terrain. 3. Primarily block-type oil pools.	Zhuangxi ancient buried hill oil pool, Renqiu oil field.
	Stratigraphic overlap oil pools	1. Stratigraphic overlap planes are matched with baseplate impermeable strata. 2. Stratigraphic overlap lines intersect structural contour lines. 3. Primarily strata-type oil pools.	Danjiasi oil field
	Stratigraphic unconformity oil pools	1. The impermeable strata or asphalt and heavy oil of the unconformity are blocked off. 2. Stratigraphic overlap unconformity lines intersect structural contour lines. 3. Mainly strata-type oil pools.	Jinjia oil pool
Compound stratigraphic-lithologic oil pools		1. Stratigraphic overlap lines and lithologic thinout lines are matched with structural contour lines. 2. Block-type and strata-type oil pools.	Zhongshi oil field

is determined by the location of the sand bodies in the lake basins, by the direction and pattern of sandstone thinout lines and by the matching relationship they have to different categories of structures. Compound sandstone bodies formed of polyrhythmic strata are associated with depression slope zones or the slopes of large-scale uplifts. They formed large and medium-scale sandstone upward incline thinout oil pools. Generally speaking, there is a large petroliferous area, several tens of square kilometers, and they have a high degree of rich accumulation. Examples include the Shuanghe oil pool in the Biyang depression and the Gaosheng oil pool in the depression to the west of the Liao He. The lithologic thinout lines of a single sandy strata group are coordinated with the location of the slopes around structures. They formed small-scale oil and gas pools and the oil-bearing area is relatively small. The oil beds are thin and there is a low degree of rich accumulation. An example is the Chaoao oil pool in the Biyang depression and the Dainan group oil pool in the Caozhuang region in the Gaoyou depression.

2) Fault-sheltered lithologic oil pools. The alluvial cones, lake-bottom fans, fan deltas and other sandstone bodies in the sloping regions along the sides of the lake basins formed a downward-sloping thinout toward the center of the lake basin and are coordinated with contemporaneous faults, forming fault-sheltered lithologic oil pools. A series of alluvial cone lithologic oil pools are distributed on the downthrown side of the large fractures at the sloping margins of the lake basins. Most are fault-sheltered lithologic oil pools. They have major changes in lithologic and physical changes, high pressure coefficients, good crude oil qualities and other characteristics. The oil-bearing areas are rather small but occur in clusters. An example is the alluvial cone lithologic oil pool at the downthrown side of the large fracture at the southern edge of the Chenjiazhuang uplift in Bin County in the Dongying depression. Some of the sandstone thinout lines in the underwater river channels on the gentle slopes of the lake basin and the lake-bottom fans are coordinated with contemporaneous faults, forming fault-sheltered lithologic oil pools. The sandy conglomeratic bodies were surrounded directly by deep water lake facies dark mudstone. There is an excellent generation-accumulation-capping combination. The individual oil beds are very thick and the accumulated oil has good physical characteristics. The oil quality is light and output is high. The scope of the oil-bearing area is rather small, but there is a rather high degree of rich accumulation. Examples include the Liaojialou oil field in the Dongying depression, the large Daling He oil pool in the Huanxiling oil field in the Liaoxi depression and others.

3) Lenticular lithologic oil pools. During stages of intense subsidence, the lake basins were affected by the surrounding fluvial water systems and the deltas or the front ends of lake-bottom fans formed areas distributed with lenticular sandstone bodies in deepwater areas of the lake regions. There are scattered sandstone bodies within the oil-generating rock bodies. There are large numbers of this type of trap in a scattered distribution. They cover a small area and belong to the class of early period primary traps, forming lithologic oil pools in which the oil was generated and reservoired in the same rock. The oil beds are thin and pressure coefficients are high.

The quality of the crude oil is good and unit area accumulations are rather small. Examples include the Sha 3 member lenticular oil pools located in the center of the Dongying, Zhanhua, Qikou and other depressions.

4) Allochemical limestone lithologic oil pools. During the period of sustained stable subsidence of the lake basins, the areas around the low underwater uplifts in the occluded or semi-occluded lake bay regions or on the shoreward side of above-water islands were conducive to the formation of allochemical and algal limestone. They were affected by changes in sedimentary facies or by secondary concretion, and there often are lithologic compaction zones at the margins of the lake shores. On the background of ancient uplifts, the lithologic compaction zones intersect with structural contour lines, forming allochemical limestone lithologic oil pools. The oil beds are rather thin and the physical qualities of the accumulated oil are good. The oil is of a light quality and output from a single well is high. Examples include the Zhouqingzhuang region in the Qikou depression, the southern slope of the Dongying depression, the Gaosheng oil field in the Liaoxi depression and other allochemical limestone lithologic oil pools.

5) Fissure interlayer suture lithologic oil pools. Under the effects of structural fracturing activity and secondary activity after diagenesis, regions of vertical fissures and interlayer sutures can develop in strata of dense but brittle dolomite, oil shale, mudstone and eruptive rock, forming excellent reservoir spaces and filter channels in local areas. Fissure interlayer suture lithologic oil pools formed on a background of structural fracturing to a certain degree. Generally, they are very near to the region of oil-generating rock distributions and form a combination in which oil is generated and reservoired in the same rock. There are major changes in the oil beds and the fissures are unevenly distributed. There is no regularity in the scope of oil content. The oil quality is good and initial output is high, but output is unstable. Based on the category of dense rock strata and the differences in the elements that formed their fissures and sutures, they can be divided into: mudstone suture oil pools like the mudstone suture oil pool in the Qianjiang depression; oil shale and dolomite fissure interlayer suture oil pools (the Jijiawu oil pool in the Huanghua depression); and, volcanic rock cone or eruptive rock strata fissure oil pools like the Sha 4 oil pool at Fengheying in the Langgu depression.

6) "Bedrock" block fault overlap unconformity oil pools. Separation and transformation during Tertiary block-fault activity formed pre-Tertiary "bedrock" fault-block mountains. A long period of erosion and dissolution of the ancient rock formed ancient landform uplifts with developed suture holes. Under conditions of multiple instances of transgression in the lake basins, the lake facies oil-generating rock strata directly overlap as an unconformity on top of the "bedrock" blocks, forming an oil formation combination of "generation in newer rocks and reservoiring in older rocks." The unconformity planes are associated with fault planes or with impervious strata at the lower plate, forming "ancient buried hill" oil pools. On a background of tilted fault blocks, the Shahejie group oil-generating rock system in the Tertiary depressions directly overlaps as an unconformity on top of the block-fault

mountains formed at different times or of differnt rock types. There was a corresponding formation of "ancient buried hill" oil pools composed of different classes of rock. Examples include the pre-Cambrian sutured granite oil pools at Xinglongtai, the Cambrian algal limestone block-type oil and gas pool at Renqiu, the Ordovician system fissured limestone oil pool at Yihezhuang and Zhuangxi, the Mesozoic volcanic rock block-type oil pool at Shijiutuo and the Mesozoic sandstone stratified oil pool at Yibei. All of the "ancient buried hill" oil pools in the Bohai Gulf Basin belong to the oil formation class of "oil that is generated in new rock and reservoired in old rock." The oil-bearing well segment is long, several hundred meters, and the oil quality is good. They are mainly block-type oil pools. Oil well output is related to the lithology of the reservoir strata and the development of fissures and holes.

7) Stratigraphic-lithologic oil pools. A suite of cyclical sediments moving from coarse to fine developed during the periods of transgression during the primary stage of development of the lake basins. The dense overlapping impermeable strata moving from bottom to top in the direction of the margin formed excellent top and bottom plate sheltering strata. A mudstone capping stratum at the top is found on an even wider scale than sand bodies, and the stratigraphic overlap lines intersect structural contour lines, forming stratigraphic overlap traps. Such traps are found very close to oil-generating depressions and have abundant oil sources and good generation-accumulation-capping combinations. The reservoir strata have fairly good physical qualities. There are certain regular changes in the quality of the crude oil, from the heavy oil at the margins to the lighter-quality oil toward the interior. The oil-bearing scope is rather large and there are many oil-bearing strata systems. There is a fairly high degree of rich accumulations. The Xiandanjiasi oil field in the Dongying depression is an example.

8) Stratigraphic unconformity oil pools. On a background of tilted fault blocks, the margins of the gentle slopes of the depressions were subjected to intense erosion by block-fault activity during the later period (it is possible that traps of earlier periods were destroyed to different degrees). Stratigraphic unconformity sediments during later periods formed a new combination of stratigraphic unconformity traps. There are two classes of unconformity plane closure conditions based on the nature of the impermeable strata of the stratigraphic unconformity: bitumen and heavy oil plugs near an unconformity like the Shuguang oil field in the Liaoxi depression, and fluvial-swamp facies mudstone plugs near the top of an unconformity, like the Jinjia oil pool on the northern slope of the Dongying depression. This type of oil pool is buried at shallow depths. The oil-bearing area is large and the oil beds are thick, but the oil is of a heavy quality.

9) Compound stratigraphic-lithologic oil pools. Under control by dual factors of stratigraphic overlap unconformity and sand body lithologic changes, strata overlap lines and lithologic thinout lines are coordinated with structural contour lines, forming compound stratigraphic-lithologic oil pools. A typical example is the Zhongshi oil field in the Qianjiang depression.

III. Categories of Stratigraphic-Lithologic Oil Pool Accumulation Zones (Regions) and a Model of Their Distribution

When a certain stratigraphic or lithologic oil pool is discovered, its existence is not accidental or isolated. Instead, they exist within a certain degree of regularity. They often are distributed in clusters and belong to a specific class of geological conditions. Those with an identical structural background are subject to control by similar changes in lithology and lithofacies, the same stratigraphic overlap unconformity and other factors. They form similar categories of stratigraphic-lithologic oil pool combinations during the process of oil and gas formation, migration and accumulation that are known as stratigraphic-lithologic oil pool accumulation zones (regions). Different types of stratigraphic-lithologic oil pool accumulation zones (regions) are formed in different types of basins or at different positions in similar classes of basins, by different sedimentation systems, by different reservoir rock bodies and by different stratigraphic overlap unconformity conditions. This is very important for coming to grips with the distributional regularities of stratigraphic-lithologic oil and gas pools and for doing effective prospecting work. The zones may be divided into eight overall categories of stratigraphic-lithologic oil pool accumulation zones (regions).
1) Sandstone upward incline thinout lithologic oil pool accumulation zones (regions); 2) lenticular lithologic oil pool accumulation zones (regions);
3) fault-sheltered lithologic oil pool accumulation zones (regions),
4) allochemical limestone lithologic oil pool accumulation zones (regions),
5) fissure interlayer suture lithologic oil pool accumulation zones (regions),
6) stratigraphic unconformity oil pool accumulation zones (regions);
7) stratigraphic overlap oil pool accumulation zones (regions), and
8) stratigraphic overlap unconformity "bedrock" block oil pool accumulation zones (regions).

Using the Dongying depression as an example, a distributional model for the various classes of stratigraphic-lithologic oil pool accumulation zones (regions) in the fault-subsidence basins has been established on the basis of systematic analysis and research concerning the stratigraphic-lithologic oil pool accumulation zones (regions) in the fault-subsidence basins of eastern China. Under control by fluvial and lake sedimentation systems, various types of reservoir rock bodies developed at different locations in the fault-subsidence lake basins and during different developmental stages. The outcome of multiple instances of transgression and regression is that there are many stratigraphic unconformities or sedimentary hiatuses in the Tertiary stratigraphic sequence that play a certain role in forming stratigraphic traps. Moreover, there is widespread stratigraphic overlap that overlaps not only gentle slopes but also overlaps in the direction of steep slope zones, sometimes to the extent of overlapping the higher positions of an uplift. This played an important role in the formation of stratigraphic overlap traps at the margins of overlaps. The many types of reservoir rock bodies found in the fault-subsidence basins, the many types of stratigraphic overlap unconformities and the identical locations of different structures form many classes of stratigraphic-lithologic oil pool accumulation zones (regions), and there is some regularity in their distribution. Stratigraphic overlap unconformity oil pool accumulation zones (regions) occur on the gentle slopes at

the margins of subsidences, while allochemical limestone lithologic oil pools or dolomite and oil shale fissure interlayer suture oil pool accumulation zones (regions) formed in the zone of transition from slope to deep depression. Lenticular sand body lithologic oil pool accumulation zones (regions) are found in the central parts of the depressions. Stratigraphic overlap oil pool accumulation zones (regions) formed on the steep slopes of uplifts, and fault-sheltered lithologic oil pool accumulation zones (regions) developed in alluvial cones. Moreover, stratigraphic overlap unconformity "bedrock" block oil pool accumulation zones (regions) were formed near bedrock fracturing zones, and there are sandstone upward-incline thinout lithologic oil pools on the flanks of central fracture anticline zones (Figure 6).

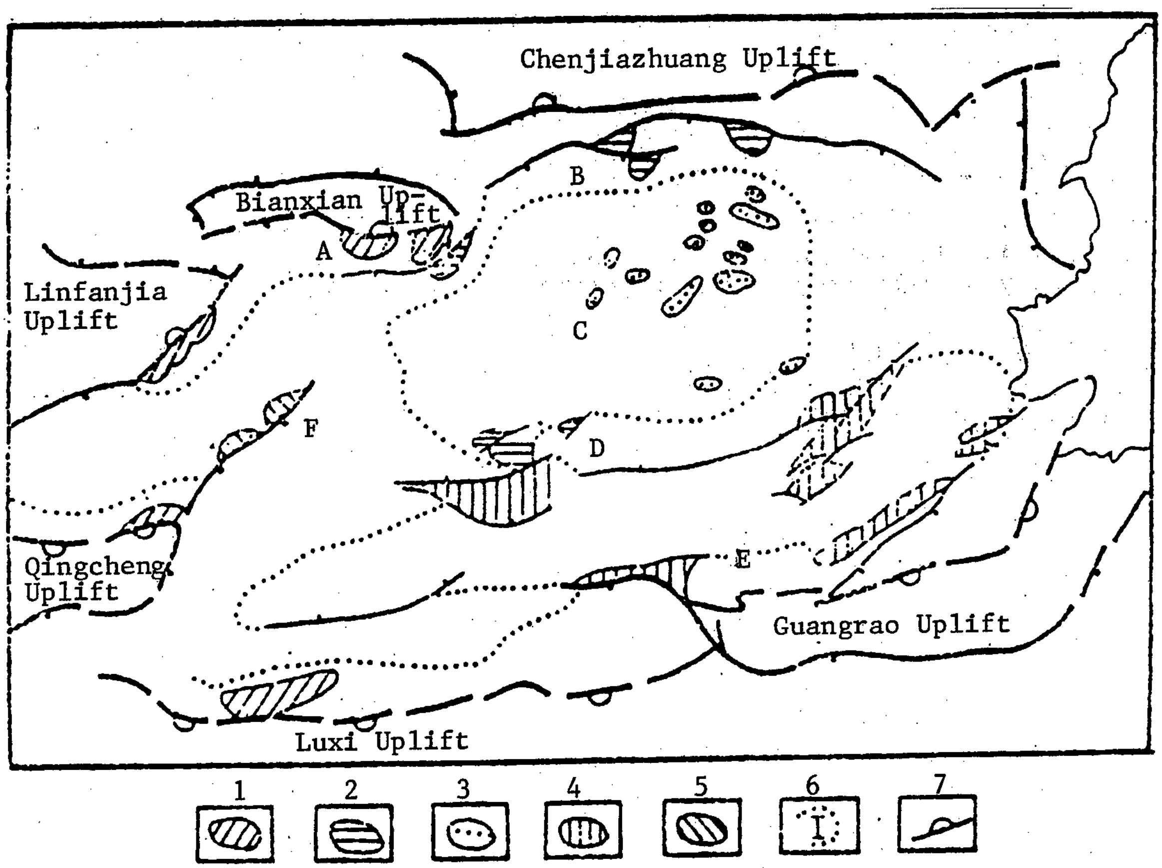

Figure 6. Stratigraphic-Lithologic Oil Pool Accumulations in the Dongying Depression

Key:
1. Stratigraphic overlap and stratigraphic unconformity oil pools
2. Fault lithologic oil pools
3. Lenticular lithologic oil pools
4. Clastic rock lithologic oil pools
5. Ancient buried hill oil pools
6. Oil and gas distribution zones
7. Stratigraphic overlap lines

A. Stratigraphic overlap oil pool accumulation zones
B,D. Steep or gentle sloping fault sheltered lithologic oil pool accumulation zones
C. Lenticular sandstone lithologic oil pool accumulation zones
E. Stratigraphic unconformity oil pool accumulation zones
F. Ancient buried hill oil pool accumulation zones

The different geological structures and evolutionary paths of the basins and the differences in sedimentation conditions, reservoir rock bodies and degree of stratigraphic overlap unconformity development caused stratigraphic-lithologic oil pool accumulation zones (regions) to develop to different degrees in different classes of basins. Often, there are regions of rich oil and gas accumulation that occur primarily in one type of stratigraphic-lithologic oil pool accumulation zone, with stratigraphic-lithologic oil pool accumulation zones (regions) of various other types serving as supplements.

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OIL AND GAS

GEOLOGICAL FEATURES, PETROLEUM POTENTIAL OF SHAYAR UPLIFT, NORTHERN TARIM BASIN

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 6 No 1, Mar 85 pp 14-23

[Article by Kang Yuzhu [1660 3768 2691], Gu Runxu [6328 3387 5171], Jiang Bingnan [5592 3521 0589] and Huang Youyuan [7806 2589 0337] of the Ministry of Geology and Mineral Resources Northwest Petroleum Geology Bureau: "Characteristics of the Geological Structures of the Shayar Uplift in Northern Tarim and Prospects for Petroleum Exploration"]

[Text] The northern Tarim Basin refers to the broad region from 79° to 86°30' degrees east longitude and from 39°40' to 42°20' degrees north latitude. It includes the Kuqa depression in the north, the Shayar uplift in the central part and the northern slope of the Awat-Manjiaer depression in the south (Figure 1). There are widepsread oil and gas seepages in the Mesozoic and Cenozoic outcrops in the Kuqa depression, and the Yiqikelike oil pool reservoired in the Jurassic systems was discovered there in 1958. Our bureau has been involved in comprehensive development of petroleum geology surveys over an area of about 30,000 square kilometers in the Shayar uplift and on the northern slope of the Awat-Manjiaer depression. We have obtained rich geological results in the past few years, the best coming on 22 September 1984, when a high-output oil and gas flow erupted from the Shacan No 3 well in the Shayar uplift's Yakela structure. This was a major breakthrough in oil and gas survey work in the Tarim Basin and opened up new spheres, new categories and new depths for oil and gas survey work. It further perfected everyone's understanding of the oil and gas geology conditions in the region, broadened ideas in the search for oil, and revealed the prospects for finding large oil and gas fields in the Tarim Basin and especially in the Shayar uplift.

I. Formation and Evolution of the Shayar Uplift

On the pre-Paleozoic crystallized basement, the northern part of the Tarim Basin accumulated enormously thick lower Paleozoic deposits that are mainly shallow sea facies carbonatite and clastic rock structures of continental origin. Orogeny during the late Caledonian period caused the Shayar uplift to start forming and the area to the north of the Luntai fracture at its southern side was uplifted (Figure 2). The upper and lower Paleozoic systems on the uplift were eroded and rather thin remnants of them remain only on the flanks of the uplift. The three different structures in northern Tarim became

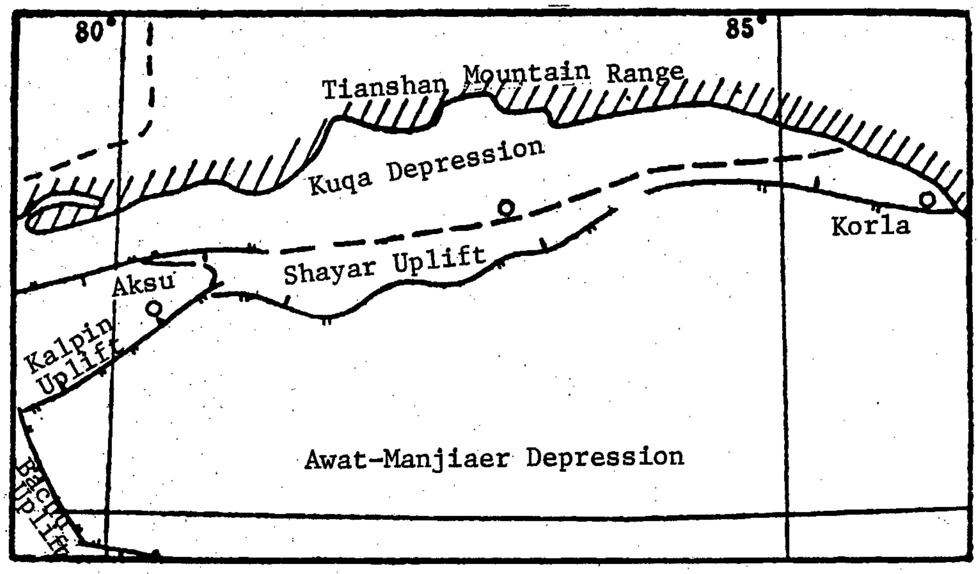

Figure 1. Outline of Structural Zones in the Northern Tarim Basin

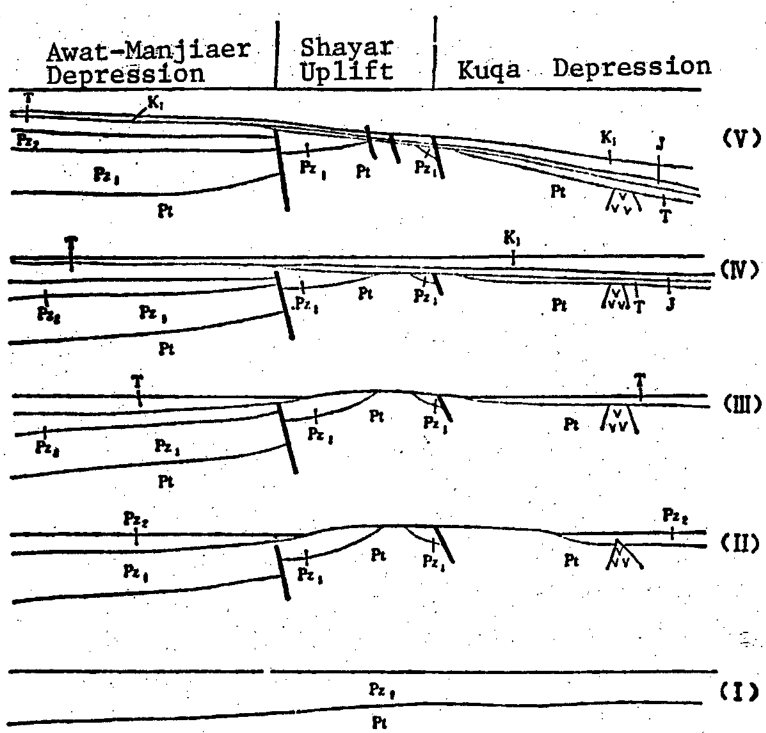

Figure 2. Evolutionary Development of the Shayar Uplift, Tarim Basin

Key: I. Caledonian period
II. Hercynian period
III. Indo-Sinian period
IV. Yanshan period
V. Xishan period

Pz_1--includes Sinian--Silurian systems
Pz_2--Devonian-Permian systems

increasingly apparent during the period of late Paleozoic sedimentation. Only on the southern and northern sides of the uplift were there accumulations of littoral-shallow sea facies clastic rock of continental origin and carbonatite. There is gradual superimposition and thinout of the upper Paleozoic moving toward the uplift, and the uplift controlled the development and distribution of sedimentation. Intense activity during the late Hercynian period at the end of the early Permian caused the Luntai fracture to become reactivated and the uplift rose even more. Sedimentation remained separated by the uplift during the Triassic, and two unconnected depressions formed at its southern and northern sides. They accumulated a suite of fluvial-lake facies and swamp facies coal-bearing clastic structures. Indo-Sinian activity at the end of the Triassic once again caused the Luntai fracture to become active and the uplift and its southern side were uplifted gradually together. The northern side of the uplift formed a single-fault type sedimentary depression. The Jurassic is superimposed moving from north to south. The sediments in the eastern part of the uplift contain a very thin Jurassic system. Another Jurassic depression formed south of the uplift in the southeastern part of the Awat-Manjiaer depression and in the Lop Nor region. The Jurassic is a suite of lake basin bog facies coal-bearing clastic structures. Cretaceous sediments were added to the deposits after the Cretaceous began. It was again uplifted and eroded during the late Cretaceous and the uplift basically had disappeared by the early Tertiary. The entire northern Tarim region formed a monocline that was high in the south and low in the north. The terrain at that time was fairly level, so the Cretaceous system developed to differing degrees within the region. This system is a suite of diluvial-fluvial-flood plain facies sediments. With the onset of the Himalayan mountains period, as the center of the basin was uplifted gradually and Tianshan at the northern margin was uplifted intensely, the northern part of the Tarim Basin formed a dustpan-shaped depression that was shallow in the south and deep in the north. The Tertiary becomes thinner and formed fewer strata moving from north to south. The Shayar uplift had been completely eliminated by this time and no longer controlled sedimentation.

II. The Sedimentary Distribution and Geochemical Characteristics of the Oil-Generating Rock in and Along Both Sides of the Shayar Uplift

Three suites of oil-generating rock developed in and along both sides of the Shayar uplift. They are the Cambrian--Ordovician systems, the Carboniferous--lower Permian series and the Triassic--Jurassic systems. Another suite, the Mesozoic Judike group also may have some oil-generating rock.

1. Cambrian--Ordovician oil-generating strata

The Cambrian--Ordovician systems are a suite of sediments that consist primarily of platform marine facies carbonatite. They are distributed mainly on the southern side of the Shayar uplift and are found on a very wide basis and in great thickness in the Manjiaer region. The long period of erosion that the Shayar uplift and the area to the north underwent means that very little of this suite was preserved there.

There are widely-distributed outcrops of the Cambrian--Ordovician systems in the Kalpin and Bachu uplifts to the west of Shayar and the Kuruktag uplift in the adjoining area to the east. Part of the Ordovician system was found in the region when drilling the Kong No 1 and Shacan No 3 wells.

1) Lower Cambrian

The upper part in the Kalpin region is conventional shallow-sea facies environment knotted limestone and flinty limestone interbedded with siltsone deposit that have produced trilobite fossils. The lower part is dolomite interbedded with bituminous limestone and dolomite. The lowest part is phosphorous- and silicon-bearing limestone strata. It contains trilobite, brachiopod, ancient crustaceans and other groups of small shellfish and animal fossils. The strata in this suite have obvious characteristics of deposits under reduction conditions in a below-tide low energy zone. They are an excellent oil generation environment and are 183 meters thick. The upper part in the Kuruktag region is mainly arenaceous and argillaceous limestone interbedded with flinty limestone, knotted limestone and shale. It contains trilobites, brachiopods, monoplachofora, gastropoda, and other types of fossils. The lower part is mainly siliceous rock and is interbedded with phosphorous-bearing strata at the bottom. The thickest interbeds were formed from basic eruptive rock and generally range from 30 to 100 meters in thickness. They may reach a maximum thickness of several hundred meters.

2) Middle and upper Cambrian

The upper part in the Kalpin region is shallow sea-lagoonal facies gypsum and dolomite formations. The lower part is shallow sea facies carbonatite deposits. Insects and trilobites are the main biological groups it contains. There also are a few interbeds of biolimestone and wormkalk, which shows that the seawater energy was a bit higher here. It reaches a thickness of 90 meters. The upper part in the Kuruktag region is mainly thick strata of brecciated limestone interbedded with flinty limestone and is about 500 meters thick. The middle part is oolitic, wormkalk and brecciated limestone, as well as argillaceous limestone, and is 200 to 500 meters thick. The lower part is mainly thin strata of limestone and argillaceous rock and is 90 to 150 meters thick. It is rich in trilobites.

3) Lower Ordovician

The lower part of the Kalpin region is dolomite with bands of flint and dolomitic limestone. The upper part is lumpy limestone and argillaceous limestone that is rich in cephalopodia, trilobites, and other fossils, and it is 469 meters thick. The upper part in the Kuruktag region is limestone and myrmekitic limestone. The lower part is alternating strata of laminated limestone and calcereous shale. It contains graptolite and trilobite, cephalopoda and other fossils, and is 500 to 1,000 meters thick.

4) Middle Ordovician

The lower part in the Kalpin region is black shale rich in graptolite and trilobite fossils. They are products of a below-tide low energy zone reduction environment and have excellent oil generation conditions. The middle and upper parts are mainly argillaceous limestone, marl and limestone that is interbedded with a small amount of clastic rock and rich in cephalopoda fossils. The total thickness is 180 meters. There are irregular alternating strata of limestone, sandy shale, battie and siliceous rock in the Kuruktag region. It is rich in graptolite and fossils and is more than 100 meters thick.

5) Upper Ordovician

In the Kalpin region, this series is mainly fine clastic rock and carbonatite. It is rich in graptolite and trilobite fossils and has the characteristics of deposits under below-tide low-energy zone reduction conditions. It preserves organic matter rather well but is not very thick, only a few tens of meters. The Kuruktag region has thin strata of limestone and argillaceous limestone. It is rich in coral, trilobites, zooecia and other fossils,and is more than 200 meters thick.

The top and bottom of the Cambrian--Ordovician systems have not been found in the Baochu region. They are composed mainly of limestone and dolomite interbedded with a small amount of clastic rock. They are rich in cephalopod, gastropod, trilobite, crinoid and other fossils, and they reach a thickness of 1,200 meters.

In summary, the Cambrian--Ordovician system is a suite of sedimentary structures dominated by platform-type marine facies carbonatite that are widely distributed and of enormous thickness in some areas. Interpretation of seismic information indicates that the total thickness exceeds 4,000 meters in the Manjiaer region (the oil-generating strata are estimated at 500 to 1,500 meters thick). There was stable sedimentation and flourishing biological life. They are rich in organic matter, and the lithology and lithofacies of most of the strata indicate that the energy of the seawater was rather low at that time and that they are a product of a reduction to weak reduction environment. They should have excellent oil generation conditions. The lack of adequate attention to these strata suites in the past, however, means that no serious research has been done on their petroliferous capacities.

2. Carboniferous--lower Permian system oil-generating strata

The Carboniferous and lower Permian systems are a suite of transgression deposits. The scale of transgression was largest during the early Permian era, but they developed primarily in the western part of the basin. Their distribution is more limited in the northern part of the basin, with a few distributed at the northern margin of the Kuqa depression. There are Carboniferous and lower Permian systems of limited thickness to the south of the Shayar uplift.

Outcrops at the edges and exploratory drilling data indicate that the Carboniferous system is carbonatite and terrigenous clastic rock from shallow-sea continental shelf, bay and lagoonal facies. It is possible that the eastern part is mainly coastal plain facies terrigenous clastic rock interbedded with carbonatite. It is rich in coral and in brachiopod and other fossils, and ranges from 300 to 2,000 meters in thickness, including 50 to 400 meters of oil-generating rock. The distributional scope of the lower Permian system is broader than that of the Carboniferous and is shallow-sea and tidal flat facies carbonatite and clastic rock that is interbedded with quite a bit of basic eruptive rock and volcanic clastic rock. The thickness as interpreted from seismic data is generally 500 to 2,500 meters, including oil-generating rock 30 to 200 meters thick.

The results of analysis of surface samples of the Carboniferous and lower Permian oil-generating rock indicate that it contains a low degree of organic matter. The organic carbon content was 0.07 to 0.2 percent in limestone and 0.3 to 1.3 percent in mustone. The hydrocarbon content is 15 to 60 ppm and the chloro-asphalt A content is 30 to 100 ppm, which meets oil-generating rock standards. The organic matter is primarily of group III, with a small amount of group II. The reflectivity R_0 from the lens bodies was 0.6 to 1.83 percent. Thermal evolution is at the mature to highly-mature stage.

3. Triassic-Jurassic system oil-generating strata

1) Triassic system oil generation strata

The Triassic system is distributed over an area of about 150,000 square kilometers in the Kuqa depression and in the Awat-Manjiaer depression. The lower Triassic is fluvial facies coarse clastic rock sediments. The middle and upper Triassic systems are river floodplain, lake and marsh facies sediments. They are mainly grayish-green and dark gray mudstone, carbonized mud and shale interbedded with thin strata of argillaceous siltsone, sandstone and dolomite. The upper part is interbedded with coal strata and is rich in plant fossils. It also has a small amount of lamellibranchiata, mussels, estheria, tadpole shrimp as well as charophyceae, sporo-pollen and other fossils, and ranges from 500 to 2,000 meters thick. Quite a few varieties of fossils are of unknown origin. For this reason, it is felt that Triassic system in this region may be interbedded with marine facies.

Dark argillaceous rock is fairly well developed in the Triassic system. The dark argillaceous rock on the northern slopes of the Awat-Manjiaer depression increases in thickness going from west to east, moving from 188 to more than 320 meters thick. This is accompanied by gradual increases in the amount of organic matter, which indicates that a sedimentary depression with better oil-generating conditions existed in the eastern part of the depression. Analysis of samples from some wells shows an average organic carbon content of 0.51 percent in the Acan No 1 well, 0.66 percent in the Shacan No 1 well and 0.79 percent in the Yuecan No 1 well. The average hydrocarbon content was 148, 110.5 and 109 ppm, respectively. Most of the organic matter is from Group III, with only a few samples on the boundary between Groups II and III. For the degree of thermal maturity of the organic matter, the reflectivity of the lens bodies in samples from the Yuecan No 1 well is 0.6 to 0.68 percent. The ground temperature gradient, however, increases gradually moving from east to west. It is 1.8°C/100 meters in the Yuecan No 1 well and increases to 2.8°C/100 meters in the Acan No 1 well. This indicates a tendency toward a greater degree of evolution of the organic matter moving from east to west. In comparison, the ground temperature gradient in the Yiqikelike oil pool in the Kuqa depression in the northern part is 2.5°C to 3°C/100 meters. This indicates that the degree of maturity of the organic matter has a tendency to become lower moving from north to south. The conversion coefficient (hydrocarbons/organic carbon) is generally <1.5 percent. To summarize the above information, the Triassic system has moderate to slightly poor oil-generating rock.

2) Jurassic system oil generation strata

These are distributed primarily in the Kuqa depression and in the southeastern part of the Awat-Manjiaer depression. It is possible that there are rather thin deposits in the eastern part of the Shayar uplift. They cover a total area of about 80,000 square kilometers. The Jurassic system in the Kuqa depression is fault-subsidence type fluvial and lake bog basin facies sediments. The Jurassic system in the Awat-Manjiaer depression is lake and marsh facies sediments and is a suite of coal-bearing clastic rock formations composed primarily of grayish-green and dark gray mudstone, shale and sandstone that is interbedded with coal strata in the middle and lower parts. The top part is interbedded with dolomite and oil shale. The bottom is grayish-white sandy conglomerate of varying thickness. It is rich in lamellibranchiata, estheria, gastropoda, chelonia and fish, as well as charophyceae, plant, sporo-pollen and other fossils. They are 275 to 2,040 meters thick and include 200 to 500 meters of dark argillaceous rock that is conducive to oil generation.

a) The lower Jurassic Yangxia group: The average organic carbon content is 2.14 percent. Chloro-asphalt A is 660 ppm. The organic matter is from Group III and has an oil generation potential of 0.16 to 1.14 mg/g of organic carbon. It is low-maturity oil-generating rock that is of fairly poor to fairly good quality.

b) The middle Jurassic Kizil Nor group: It has a fairly high degree of organic matter, with an organic carbon content of 1.05 to 2.29 percent and averages 1.47 percent. Chloro-asphalt A is 179 to 1,000 ppm and averages 563 ppm. The oil generation potential is 0.44 to 2.45 mg/g of organic carbon and averages 1.44 mg/g of organic carbon. The organic matter groups are mixed types and humus types. The OEP value is 1.52. It is fairly good low-maturity oil-generating rock.

III. Structural Characteristics of the Shayar Uplift

The Shayar uplift is located between the Kuqa depression and the Awat-Manjiaer depression, and is oriented in an east-west manner. It is wider in the west and narrower in the east. It is 460 kilometers long from east to west and 10 to 50 kilometers wide from north to south. It is bounded on the south by the Luntai fracture and the Awat-Manjiaer depression.

The Shayar uplift is an ancient bedrock uplift and the Osozoic and Cenozoic systems lie directly as an unconformity on top of different pre-Mesozoic strata positions (Figure 3).

The Shayar uplift is abutted on the west by the Kuruktag uplift and by the Kalpin uplift. Geoseismic information indicates that there is a gradual steepening of the basin toward the west and toward the east, which is linked to the Shayar uplift that lies in an east-west orientation (Figure 4). This separated the late Paleozoic and Mesozoic sedimentation depressions and controlled the development and distribution of sedimentation.

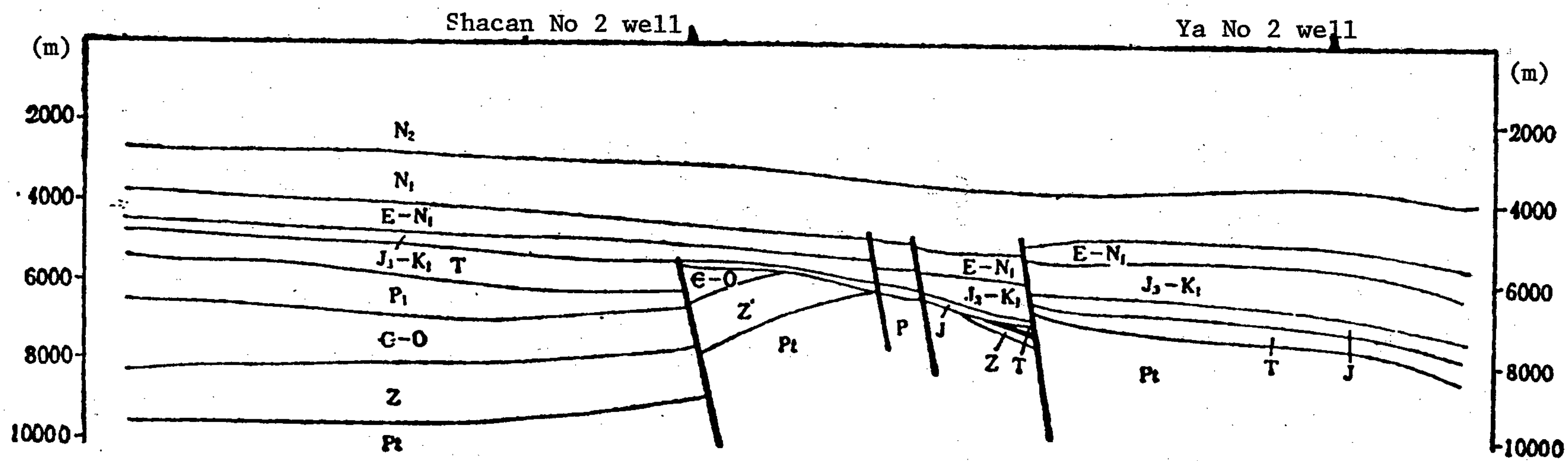

Figure 3. Illustration of the Geological Profile From the Shacan No 2 to Ya No 2 Wells

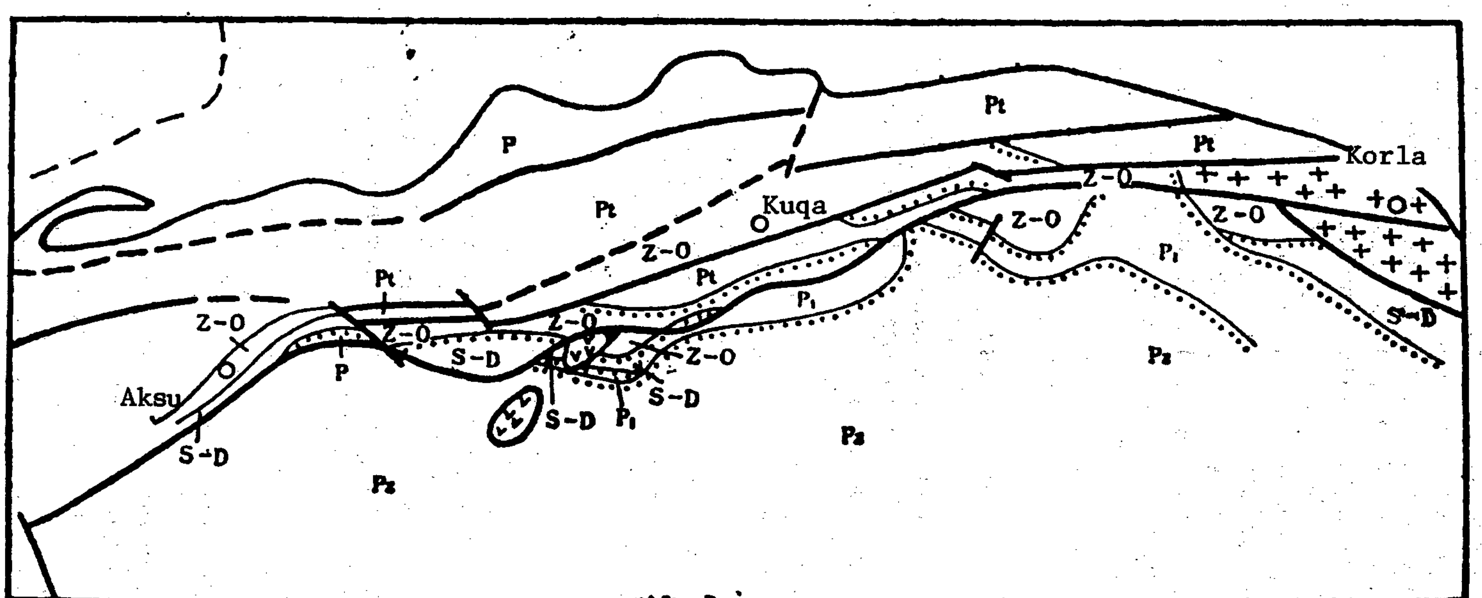

Figure 4. Geological Structures in the Northern Tarim Basin at the End of the Hercynian Period

Three groups of fractures running in different directions formed in the Shayar uplift. They are oriented primarily in an east-west or ENE direction, with a few having a NW orientation. They are mainly compressive fractures with a few extension and torsional fractures. The faults caused by compressive fracturing generally have fault planes that are inclined to the north and that are steeper at the top and gentler at the bottom. These faults have a large displacement and extend for a considerable distance. They have the characteristics of long-term activity. The fractures caused by extension and torsion generally are small in scale and have fairly steep fault planes.

These three groups of fractures divided up the uplift into a series of fault blocks of different shapes, sizes and heights. At the same time, compression or extension caused by fracturing activity along one or both sides of a fracture formed a series of folds that lie parallel or at an angle to the fractures. Seven regional structures that may be traps already have been discovered.

IV. The Geological Conditions of Oil Formation in the Shayar Uplift

The oil that came out of the Shacan No 2 well turned the potential for oil and gas in the Shayar uplift from conjecture to reality and confirmed that it is a region of very great prospects for oil and gas.

1. Abundant oil sources

Three important suites of oil-generating rock developed in the northern part of the Tarim Basin. This is especially true of the Awat-Manjiaer depression which has complete development of the three suites of oil-generating rock that are distributed over a wide area and that are of great thickness. The Cambrian--Ordovician systems are the most important in terms of comparative area and thickness. The Triassic-Jurassic systems are second. There are oil-generating depressions adjoining the Shayar uplift at its southern and northern sides. The oil source region is very near and it has been an area of straight migration of oil and gas. It could receive continual replenishment of oil and gas from the oil source regions at the southern and northern sides. There was a blowout at the Shacan No 2 well lasting for more than 50 days without letup. It provided adequate proof of the rich oil sources in the Shayar uplift.

A geochemical analysis of the crude oil from the Shacan No 2 well shows a high vanadium (5.88 ppm) and nickel (0.76 ppm) content and a very high vanadium/nickel ratio (7.76). Chromatographic analysis of the saturated hydrocarbon in the crude oil indicates a superior carbon coefficient for C_{28}, C_{30} and C_{32}, and a CPI = 0.988 situation. It is felt that it is marine facies crude oil. When these two suites of Paleozoic marine facies oil-generating rock are compared, the Carboniferous--Permian systems have a more limited distribution, thinner sediments and poorer lithological and lithofacies conditions. For this reason, one view is that the oil and gas in the Shacan No 2 well came from Cambrian--Ordovician system source strata.

Triassic sporo-pollen fossils were discovered after analysis of the sporo-pollen in the crude oil, however. The greatest proportion of the sporo-pollen groups, 70 percent, was accounted for by fern spores. Calamospora, Punctatisporites and Todisporites were seen most often in the groups and there also were quite a few typical Triassic Aratrisporites components. When combined with a consideration of the fact that the Yuecan No 1 well in the Triassic system contained a large amount of fossils of dubious origin, a second view is that the crude oil in the Shacan No 2 well came from Triassic--Jurassic source strata.

It is possible, of course, that the crude oil in the Shacan No 2 well came from two or more different oil-generating strata (including the Carboniferous--Permian systems). With the establishment of a view of multiple sources of oil and gas, then there would be oil sources in the Shayar uplift.

2. Excellent development and quality of reservoir strata

Like the northern part of the Tarim Basin as a whole, the Shayar uplift developed three different reservoir strata to different degrees.

1) Porous reservoir strata composed of clastic rock

These developed to different degrees through all the periods and are most concentrated in the lower Cretaceous--lower Tertiary, the lower part of the Mesozoic system and in sandstone. Each stratum generally is 5 to 20 meters thick and may reach a maximum thickness of more than 100 meters. The cement of the sandstone is mostly argillaceous and limestone material. The type of cementation is primarily porous-type and contact-type cementation. The results of analysis of a small number of samples indicates a porosity of 6 to 21 percent and a permeability of 11 to 1,700 milliDarcys. The material conditions are excellent.

2) Suture-hole type reservoir strata composed of carbonatite

The carbonatite of the Cambrian--Ordovician systems, and the Carboniferous-lower Permian systems reaches a total thickness of more than 3,000 meters. Primary pores, secondary pores, fissures and solution holes are highly developed in the carbonatite. They generally are about 1 mm wide and can reach 3 mm or more. Examination under the microscope indicates that pores account for about 5 percent of the area of the rock fragments and that they are well connected. The width of fissures is generally 1 to 5 microns. The solution holes usually are about 5 microns and the largest can reach 200 microns.

3) Reservoir strata with development of secondary pores in a weathered crust

This region has undergone several periods of activity and has formed many sedimentary profiles. Each period of sedimentation was cut off and underwent a long period of weathering and erosion. This formed weathered zones of substantial thickness and secondary holes and fissures developed in each of the weathered zones. There are five sedimentation cutoff profiles that

deserve attention at the present time. The first is between the Pliocene and Miocene systems. The second is between the Miocene and lower Tertiary systems. The third is between the Mesozoic and Cenozoic eras. The fourth is between the Mesozoic and Paleozoic eras. The fifth is between the Carboniferous system and strata from the Devonian systems or below. The sedimentation profiles between the Mesozoic and Paleozoic and between the Mesozoic and Cenozoic are of regional significance.

Faster drill speeds and drill vacuum discharge often arise when limestome or dolomite weathered zones are encountered during drilling. Many wells have leaked and the maximum mud leakages have exceeded 600 cubic meters. This indicates the development of fissures and holes in the carbonatite and its high porosity and permeability capacities.

3. Many types of traps

There are many types of traps in the Shayar uplift and along its sides. There are continuous anticlines associated with bedrock uplifts, folded capping strata that are related to activity in later periods and other structural areas. There are fault-block traps associated with fracturing activity. There are some stratigraphic traps associated with sediment thinout or structural erosion and thinout, and there are many types of complex traps. Seven types of traps covering an area of more than 1,000 square kilometers have been discovered in the uplift to date, and all of them provided sites conducive to rich accumulations of oil and gas.

4. The importance of fractures for oil and gas migration and accumulation

Criss-crossed longitudinal and latitudinal fractures developed in the Shayar uplift. Although they run in different directions and were active at different times, these fractures play an important role in the process of oil and gas migration and accumulation and in the formation of oil and gas pools. All of the oil and gas pools that have been discovered to date in the basin are extremely closely linked to fractures. Examples include the Kekeya oil and gas pool, the Yiqikelike oil pool and the Yakela oil and gas pool. All of them have several fractures below or around the oil pools, but there are no solidly filled structures associated with the fractures. Despite the fact that the structures are complete and that the traps are excellent, no good oil and gas indications have been found after drilling to more than 7,000 meters. For this reason, we should pay attention to the principle of "prospecting along the high points of fractures."

5. The Shayar uplift occupies a favorable structural position

The Shayar uplift is located between the Kuqa depression and the Awat-Manjiaer depression. In terms of present strata occurrence, the Paleozoic on the southern side is inclined downward moving from north to south. There is no doubt that the oil and gas generated in Paleozoic strata migrated from south to north. On the northern side, the Mesozoic and Cenozoic rise up moving from north to south. Oil and gas formed in the Triassic--Jurassic systems certainly would have migrated from north to south. This means that the

Shayar uplift was capable of receiving oil and gas that migrated from both the southern and northern sides. This is definitely a hard to come by favourable structural position for rich accumulations of oil and gas.

6. An analysis of the categories of oil and gas pools at Yakela

The petroliferous strata in the Yankela oil and gas pool is Cambrian--Ordovician system dolomite. It occurs on a gentle southward-sloping monocline. It is capped by the Jurassic system and is closed by the Luntai fracture on the southern side. The unconformity displays a low degree of structure and does not match that at the Shacan No 2 well. It is conjectured, therefore, that the scope of oil control may exceed the scope of the structural traps and that the elevation of the oil pillars is higher than that of the structural traps. For this reason, it is possible that the Yakela oil and gas pool is a fault-block oil and gas accumulation that is related to fracturing and a weathered crust.

In summary, the Shayar uplift has extremely excellent geological conditions for oil formation and is a very promising zone of rich oil and gas accumulations. It is an important region in the search for large oil and gas fields. When comparing the different positions on the Shayar uplift, the geological conditions for oil formation in the central and eastern parts are better than in the western part. One reason is that they are much closer to the source region and to the Mesozoic and Paleozoic oil-generating depression at Manjiaer--Caohu. Moreover, there was concentrated development of fractures and local structures. Furthermore, the target strata are buried at more shallow depths (4,500 to 5,500 meters). The surface geological conditions are better, communications are convenient, and there are other favorable elements as well. This means that the search for large oil and gas fields can start there. Forces can be concentrated for exploration and excellent results certainly will be achieved.

V. The Prospects for Finding Oil in Other Regions of the Northern Tarim Basin

There also is a very broad region for oil exploration in the northern part of the Tarim Basin besides the Shayar uplift. Not only can oil and gas pools that were generated and reservoired in the same strata be found in the internal structures of oil-generating strata systems, but secondary oil and gas pools also may be found in shallow strata above the oil-generating strata. Surface structures and fractures are fairly developed in the northern part of the Kuqa depression and local structures arranged in rows or belts have been found. This is especially true of the concentrated salt dome pierced structures in the western part. This is a class of trap that deserves attention. Major discoveries may be possible with a breakthrough. In addition, we also can select some local structures in the anticline of the already-discovered Yiqikelike oil pool as well as the similar Chiulitake anticlinal zone and in the gentle southern anticlinal zone, and do more work there. Trap structures or possible trap structures already have been discovered at Keteur, Alar, Shaxi, and Caohu at the southern side of the Shayar uplift and on the northern slopes of the Awat-Manjiaer depression. These structures developed in the Paleozoic. They have a large structural area, a high degree of closure and

excellent traps. It is even closer to the source region than the Shayar uplift, and is an area that the oil and gas must have passed through during migration. It is another area that is conducive to rich accumulations of oil and gas outside the Shayar uplift. It also is another important region in the search for large oil and gas fields.

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OIL AND GAS

COAL GAS RESOURCES IN NORTH CHINA EVALUATED

Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese Vol 6, No 1, Jan 85 pp 31-40

[Article by Zhou Xinxi [0719 5281 3556], Yuan Rong [5913 1369], and Li Xuexin [2621 1331 2450]]

[Summary] The southern part of the North China basin is a region with widely distributed coal series of the Late Paleozoic age. Because of its abundant coal resources, this region provides a good source of coal gas. In this article, the author presents a technique for objectively evaluating the effective gas-producing capability and gas resources of this entire region by studying the burial-thermal evolution of the coal series. Specifically, he describes a procedure which is based on measuring the reflectivity of xylovitrain and reconstructing the history of burial-thermal evolution using the method of Lopatin and Waples.

The history of thermal evolution of this region can be divided into four different stages: the stage of uniform evolution, the stage of differential evolution, the stage of overlapping evolution, and the stage of depletion. The last two stages are of particular importance because the coal gas produced by the secondary burial process which occurred during this period was effectively preserved. In terms of the burial characteristics, the basin can be classified into five different types: Y, N, U, W and V. These regions differ considerably in thermal evolution; therefore, their effective gas producing capacity, effective gas producing period, and projected coal gas reserve also differ a great deal. Because of its long burial period and high degree of thermal evolution, the Y-type region is considered to be the most promising in terms of coal gas reserves.

By using the xylovitrain reflectivity data published by the Soviet Union in 1977 and the average gas productivity given by V.P. Kozlov in 1961, a curve of xylovitrain reflectivity versus apparent gas productivity for each sub-region as well as the entire region can be estimated. In terms of the likelihood of coal gas preservation, three different estimates of coal gas reserves in this region are obtained: (1) purely theoretical estimate of gas productivity--85.222 x 10^{12} m^3; (2) effective estimate of gas productivity--14.685 x 10^{12} m^3; (3) more effective estimate of gas productivity--11.6045 x 10^{12} m^3.

OIL AND GAS

RESULTS OF SWITCH TO PUMPING IN DAQING FIELDS REPORTED

Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese Vol 6, No 1, Jan 85 pp 71-80

[Article by Peng Pengshang [1756 7720 0794] and Li Kangmei [2621 2123 5019]]

[Summary] In a water-pressurized oil field, as the water content increases, the minimum flowing pressure begins to rise, thus reducing the pressure differential and the level of oil production. At the Daqing oil fields, it was decided that the flowing method of production must be replaced by mechanical methods in order to maintain productivity. Since 1981, 544 wells of the Daqing field have been converted to mechanical pumping, and a 60 percent increase in average production was achieved.

However, when the flowing pressure drops below the saturation pressure as a result of pumping, three-phase permeable flow will appear, and new conditions for oil extraction are created. Under these circumstances, the technical constraints, permeability characteristics, and pumping procedures should be carefully re-examined. In this article, the author presents a theoretical discussion and a statistical analysis of changes in the productivity index as the flowing pressure falls below saturation pressure. He claims that while the productivity index decreases under these conditions, the dropping pressure will reduce inter-stratal interference, increase the thickness of oil drainage, and limit the drop in productivity index. An analysis is also presented to determine the flowing pressure limit, the stratal pressure limit, and the pressure limit of injected water of the wells.

In conclusion, the author suggests the following procedures to improve the results of pumping: 1) using the method of regional integrated pumping; 2) pumping the oil-water transitional belts first before other areas; and 3) coordinating pumping with adjusted water injection.

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OIL AND GAS

BRIEFS

SHENGLI MID-YEAR PRODUCTION--In the first half of 1985 crude oil production of the Shengli Oilfield in Shandong Province reached 13.32 million tons, an increase of 2.98 million tons over the ocrresponding period of 1984. Shengli Oilfield also fulfilled 2.11 million meters of well drilling and footage, equal to the total 1984 footage figure. [Summary] [Jinan Shandong Provincial Service in Mandarin 2300 GMT 1 Jul 85 SK]

JILIN MID-YEAR OUTPUT--As of 30 June, the Jilin Provincial Oilfield Management Bureau produced 1,042,927 tons of crude oil, fulfilling the annual plan by 65.2 percent, and a 10.9-percent increase over the corresponding period of 1984. Total industrial output value reached 108.52 million yuan, fulfilling the annual target by 66.9 percent, and an increase of 12.4 percent over the corresponding period in 1984. The bureau also topped its previous highs in various other major fields. [Text] [Changchun JILIN RIBAO in Chinese 4 Jul 85 p 1 SK]

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SUPPLEMENTAL SOURCES

XIZANG MOVES AHEAD THROUGH ENERGY DEVELOPMENT

OW230830 Beijing XINHUA in English 0814 GMT 23 Jun 85

[Excerpt] Tibet accounts for one-third of the entire country's water power resources. Its geothermal tops the list in China and its solar energy is second only to the Sahara Desert. Since its founding 20 years ago the autonomous region has made great headway in utilizing them.

Departments concerned in the Tibet Autonomous Region disclosed that the region has invested nearly 300 million yuan over the past decade in energy development.

Electricity is now available to all urban cities and one-third of the region's rural areas.

Today, 701 power stations are in operation, including 679 small hydropower stations spread throughout the region. The combined generating capacity is 113,000 kW. Last year alone, the region built 22 small hydroelectric power stations with a combined generating capacity of 9,245 kW, exceeding the total before 1965, when the autonomous region was officially established.

The power supply has given a great impetus to industrial development. Electricity is now used to power pumping stations, threshing machines, and farm and sideline produce processing machines.

Geothermal development began only in 1975, when the building of the first geothermal power station started. Now the power station has a generating capacity of 7,000 kW. It has supplied Lhasa with 80 million kWh of electricity since 1982, becoming one of the key power stations in the Lhasa grid. Another 3,000 kW generating unit is being installed. When it is completed in August this year, the total generating capacity will reach 10,000 kW. In addition, 20,000 square meters of geothermal green houses were built around the geothermal field. Each square meter of land where vegetables had never been grown before, now yields an average of 15 kilograms of vegetables annually.

The development of the Langjiu geothermal field in Ngari Prefecture began last year. Ten hot water wells have been drilled and the first 1,000 kW generating unit is expected to go into operation in coming August.

Solar energy is used to boil water and cook meals and heat hot houses and baths. Beginning in 1976, the region has built 115,000 square meters of green houses, 6,000 square meters of solar bath houses and 5,000 square meters of solar-heated houses. More than 1,900 sets of solar heaters, baking ovens, and solar stoves have been distributed among local residents. Every household in Jianggar village, Dolungdeqen County, has a solar water heater and a solar stove.

Wind energy development has entered the applied stage. Last year, herdsmen in northern Tibet installed a 100w wind power generating unit for lighting and powering radio-recorder sets. Now more than 200 such power generating units have been installed in the region. The number is expected to reach more than 400 by the end of this year.

The regional authorities said that the total power generating capacity in Tibet will be brought to 500,000 kW by the end of this century according to a development plan based on the simultaneous development of hydro-electric, geothermal, solar, and wind power.

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CONSERVATION

PRELIMINARY APPROACH TO REFORMING ENERGY CONSERVATION WORK

Beijing NENG YUAN /JOURNAL OF ENERGY/ in Chinese No 2, 25 Apr 85 pp 7-9

/Article by Cheng Heping /7115 0735 1627/ of the Energy Bureau of the State Economic Commission/

/Text/ After several years of efforts to conserve energy, China has made some very large accomplishments. However, because of abuses in the present management methods and economic system, there have been serious obstacles to the full development of energy conservation. Thus, energy conservation work must be reformed. The principle factor affecting the further development of energy conservation is the tendency of energy prices to be too low. For a long time the "contract allotment" system and the absence of separation of business and government, the unenlightened administrative method of fines and rewards, caused business and worker alike to lack any feeling urgency or impetus for energy conservation. We were unable to bring into play the positive qualities of business and worker.

In 1983, following reforms in the economic system, preliminary experiments were begun in reforming energy conservation work. There were remarkable successes, especially in streamlining government and relinquishing authority, using the economic contract responsibility system, utilizing microcomputers to manage conservation. The first steps toward reform in energy conservation work had been taken.

I. Streamline Government and Relinquish Power: Divide the Levels of Management

A key point of economic reform is the streamlining of government and relinquishing of power at every level of economic management organization. In the last several years the state had been treating business too strictly, so that even a part of some depreciation funds had to be given over to the state for conservation technology transformation funds, then distributed uniformly by the state. This method of eating from the "big rice pot" resulted a lack of funds for many businesses which should have been transforming their conservation technology. Those businesses that received money were under no pressure because they need not repay the amount or pay interest, and because their energy allotment was not reduced. There was little economic benefit to this; some factories even turned the money to other uses. Accordingly, the State Economic Commission, in the spirit of "Relinquish power down to every level, power is to be relinquished according to one standard" resolved that beginning in 1985 this money

would be returned to the businesses and localities. This not only gives more autonomy to business, it also helps overcome the bureaucracy of our nation's organizations, and allow business to escape the microscopic scrutiny of bureaucratic eyes, so that they can go on to study more macroscopic questions.

The State Economic Commission proposed a model for the decentralization of the administration of conservation in 1983. Aclear line was drawn between the priorities of business on the one hand and of administrative sectors of central, the provinces, municipalities and localities, as well as overall economic sectors of the state on the other hand. This was of great benefit to studying and determining the work and duties of every organization administering energy conservation.

The first level is business, and the most important thing is to raise the quality of business at the outset, to allow for energy audits and scientific administration, to transform the technology of conservation, raise the level of operating technology, raise the efficiency of resource utilization, lower the consumption of goods and energy, and strive to reach the most advanced level of technology from home or abroad.

The second level is the central committee, and the main managerial sectors at provincial, municipal and local levels. The most important thing for them is to study the formulation of policies for conservation by industry, regulate business structures and goods structures, organize businesses' development of the transformation of conservation, and directly lead energy consuming businesses in the carrying out of conservation plans.

The third level is the central committee and the overall economic sectors of province, municipality and locality. The important thing for them is to take the large view and study the approaches to conservation as well as the goals, find an overall balance, stress social benefits, study and adjust economic structures which are favorable to conservation, enact conservation statutes and economic policies, organize, study, and promote conservation technology.

II. Try Out Energy Conservation Economic Contracts

In order to solve the problem of eating out of the "big rice pot" in the distribution and use of energy, the State Shipbuilding Corporation in 1983 ran an energy rationing experiment at the Dalien Shipyard; while the total value of the shipyard's production was rising steadily, the amount of energy supplied would remain fixed for 3 years. The results of the test were as follows: In 1983 the total value of production went up 1 percent, while the energy consumed to produce every 10,000 yuan of product went down by 7.5 percent, and their coal consumption was 5,000 tons less than the contract target. The value of production from January to September of 1984 went up 13.8 percent when compared to the same period in the previous year, while the energy consumed to produce every 10,000 yuan of product went down 8.3 percent, and coal consumption was down by 4,500 tons. In 1983 the Shipbuilding Corporation made energy rationing contracts with 29 plants and yards, amounting to 75 percent of the energy used by the corporation.

Responsibility for energy has taken many forms in a variety of localities in the course of reform. For instance the Yanzhou Printing and Dyeing Mill instituted in all its workshops a "three contract one guarantee" system (that is, contract for a consumption of a fixed amount of energy, contract to save energy in material quantities, contract to save energy to immediate effect; guarantee production and supply capabilities, use energy to produce normally). The value of the mill's production went up, energy consumption went down and the results energy conservation were obvious. The Changzhou Rubber Plant and the Benxi Steel Company entered into a general energy conservation and technology transformation contract concerning investment, time limits for projects, and results. This accelerated the forward progress of technology transformation. The Benxi Steel Company signed an agreement with the No 2 Blast Furance concerning the rebuilding of several sintering ignition burners. They instituted the "four contract one fixed" system (that is contract investment, contract time limits on projects, contract quality, contract results, fix rewards and fines). The contracted-for work period was 2 months; the job was finished 2 days early. The contracted price was 250,000 yuan; actual expenditure was 227,000 yuan. After rebuilding the ignition burners the plant's energy consumption went down 4 kg per ton of sinter, for an annual saving of 34 million tons of bituminous coal. The Changzhou Cotton Spinning Mill, in building a "leakless" mill used an economic contract, establishing an audit procedure for each of the 20,000 sealed points around the mill, made it explicit that management and repair personnel would inspect every day, and the result has been that the leakage from the pipe network in the plant has been kept to less than 0.02 percent.

Experience has shown that these energy conservation economic contracts which combine responsibility, power and profit have the characteristics of fixing responsibility, and providing clear areas for rewards and punishments. It is possible to mobilize the positive qualities of the businesses and workers, to advance the dvelopment of energy conservation, it is a management technique that works when put into effect, and which can be used on an even broader scale.

III. Use Microelectronics To Manage and Control Energy Conservation

"The third wave," of which microelectronics is typical, has broken over the field of energy conservation. Now there are many units using microcomputers to control production runs, to make energy conservation analysis, or in the design of energy saving equipment. Some preliminary success has been seen, and a new path has been opened up for the future of energy conservation.

In 1981 the Chengdu Seamless Pipe Mill installed a microcomputer control system on two ring-type furnaces and one step heating furnace. This provided automatic control of the furnace chamber temperature, pressure, and gas and air supply. The consumption of natural gas used for heating ingots decreased by 10-15 percent; the three furnaces now save 2.5 million cubic meters of natural gas per year; heat damage to the ingots has been reduced; the product yield ratio has gone up about 1 percent, each furnace can now produce an extra 500-1,000 tons of steel products per year; the useful life of the step heating furance was increased 50 percent, saving 50,000 to 100,000 yuan per year. The above measures to increase production resulted in an savings of 2 million yuan in 1 year, so the entire investment was paid back in a few months.

Shang Steel's No 5 Mill has employed a microcomputer based real-time control system to control the impulse current in 10 electric furnaces. This ensures normal production, raises the load efficiency of the power lines by over five percent, has reduced annual power line losses by 75,000 kilowatt hours; and it can provide a load of 6-7 megawatts. The mill is saving 520,000 to 610,000 yuan per year on supercurrent power bills. They also use a microcomputer control system for the entire mill's power load system which automatically monitors the power transformers and the microcomputer automatically sounds an alarm when a mill department exceeds its proper power load, or the computer will automatically control the load. This completely prevents the abuses of power loading that went on in the past. After the adoption of the microcomputer power load regulation system, the mill uses 5 megawatts less per month, and the electric bill has been reduced by 36,000 yuan. The microcomputer system cost 100,000 yuan, so it will take less than 6 months to repay the investment.

The oil refinery at the Shanghai Gaoqiao Petrochemical Company uses a microcomputer to caluculate and regulate energy consumption, as well as regulating the oil production. This has greatly reduced the time taken for energy calculation and analysis, the figures are accurate, and it is possible to adjust the figures according to demands, and print out the result. At the same time it is possible to provide all sorts of information and analysis targets, a good tool for closer management. Closed-cycle controls are used in the heating furances, which can raise the heat rate by three-four percent, each furnace can save 300-400 tons of heating oil per year, with a direct savings of 14,000 yuan/year.

The Shanghai City Energy Conservation Applied Technology Institute has used a Casio FX-702P microcomputer to organize the data on regnerative balanced heat rates for industrial boilers, and in a combustion experiment under industrial conditions, it only took 20 minutes to go from the collection of the data to the final calculation, and a record of the whole was printed out, a great advancement in calculation.

The experience in every area shows that the use of microcomputers has a positive effect on production, quality, and energy savings. Microcomputer systems are reliable, cheap, simple to se up, easy to comprehend, in all, they are a new technology with development potential. Microcomputer use should be advocated not only for energy conservation, but also to speed up the transformation of technology in business, and the progress of technology, to raise the quality of management and administration in business.

IV. Exchange Information, Increase Service

There are two problems facing small and medium sized businesses in the area of energy conservation. One is insufficient funds, the other is a lack of technology. So combat the problem of the lack of technology, there have been 120 energy conservation service centers set up nationwide. While they emphasize do-it-yourself measures, they also provide a variety of technical service work and advice to business. Since 1983 the Chongqing City Energy Conservation Service Center has completed seven demonstration projects, such as the Jianshe Machine Tool Factory central heating project and the Chongqing Knitting Mill's back pressure electrical gneeration project. They organized 52 training classes

on every type of energy, with 2,800 students. They brought together over 100 examples of new energy saving products and technologies, and held an energy conservation exhibition. The value of the energy saving products promoted at this fair came to 54.5 million yuan. In 6 months' time they entertained 78 delegations from 24 cities, and had over 100,000 visitors.

In Zhengzhou, the No 3 State Cotton Mill has subscribed to 18 conservation publications in order to gain more information. They have organized a three-tiered information network in the mill to bring the most advanced information and measures into the mill in a timely manner. For instance an article appeared in NENG YUAN /JOURNAL OF ENERGY/ in 1983 on the subject of energy saving measures for textile machinery. This information they relayed at once to the textile machinery workshop, and it was put into use after a period of experimentation. Now the energy consumption for the whole mill equals the quota for just the spinning and weaving division alone! They read of an "illumination electricity control device" in a conservation publication and they put it to work in regulating the electricity for illumination in their collective dormitories; when the load is exceeded by 10 percent it shuts off automatically, with good results. Those sectors concerned in the city science committee and city weaving company have appraised it, and now the Zhengzhou Radio Instrument Factory is making them in batch lots. Already 27 mills and mines in the Henan area are using them with good results.

The Chengdu Energy Conservation Technology Information Network has over 500 units involved, and over 80 percent of them are factories, mines and businesses. The area covered by the network accounts for half the energy consumption in the province. They readily take in all sorts of advice, by letter, telephone and word of mouth. They will undertake big technical programs and look up little things in a journal. Their attitude is "if there is a question, it must be answered." Their conservation information exchange and instruction classes have also shown good results. A major project in Sichuan is promotion of replacing coal-burning furnaces with reciprocating furnaces, and after study of the problem by a study group in the information network, the Meishan Car Factory, a network member, was able to raise its heat rate from 11-12 percent before the promotion to 14.7 percent afterward.

In 1984 an all-China conservation information network was established on the foundations of the regional information networks, to increase the spread of information, The All-China Energy Conservation Fair was held during "Energy Conservation Month," bringing together 2,000 items of interest to conservation from 27 provincial, municipal and locwl areas, as well as 100 energy saving products. Over 10,000 people from all parts of China visited during the month.

V. Revise and Establish Rules and Laws

In May 1981 the State Economic Commission and the State Planning Commission, together with the original State Energy Commission, published the "Concrete Demands for Energy Conservation by Industry, Mines, and Businesses" (58 items) and there has been a great deal of action in conservation management in these last years. However, in the course of reforming the economic structure, people in all areas began to feel that the "Demands" were no longer appropriate to the

new conditions in their areas. For instance, Shanghai City took its original "Regulations Concerning Increased Conservation Work in the City" (51 items) and revised it as "Provisional Rules for Energy Conservation by Factories and Businesses in Shanghai" (40 items), Heilongjiang province set out the "Provisional Rules for Energy Conservation in Heilongjiang Province," Hunan issued the "Provisional Methods for Administration of Energy Consumption Quotas for State-run Industries and Transportation Enterprises in Hunan Province," etc. Zhejiang, Liaoning, Shandong, Hebei, etc., have all revised and issued their province's procedures for energy conservation awards. This basic work of establishing rules for energy administration at every level in one's own province and for estimates, statistics and quotas for business; and also specific regulations for rational use of energy, the transformation of conservation technology monitoring, inspecting, and awarding fines and punishments will all cause the energy conservation efforts of business to become more scientific and on track with our legal system.

Everywhere in the administration of energy, and especially in instituting economic reforms, problems are encountered which do not lend themselves to administrative solutions. There has been a general recognition of the need for a codification of our nation's energy conservation laws, to round out our socialist legal reconstruction, and to guarantee the unhindered development of conservation work. Work has begun on drafting the "Energy Conservation Act of the People's Republic of China." The energy administration laws of all countries have been gathered together and systematized to provide use with a general outline of energy conservation law.

Although we were unable to provide a taste of all the rich variety of work in economic reform that is being carried in every locality, in every trade and by every unit, still it is possible to see that the reform of energy conservation work has already achieved some preliminary success, and there is a general trend toward further development.

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